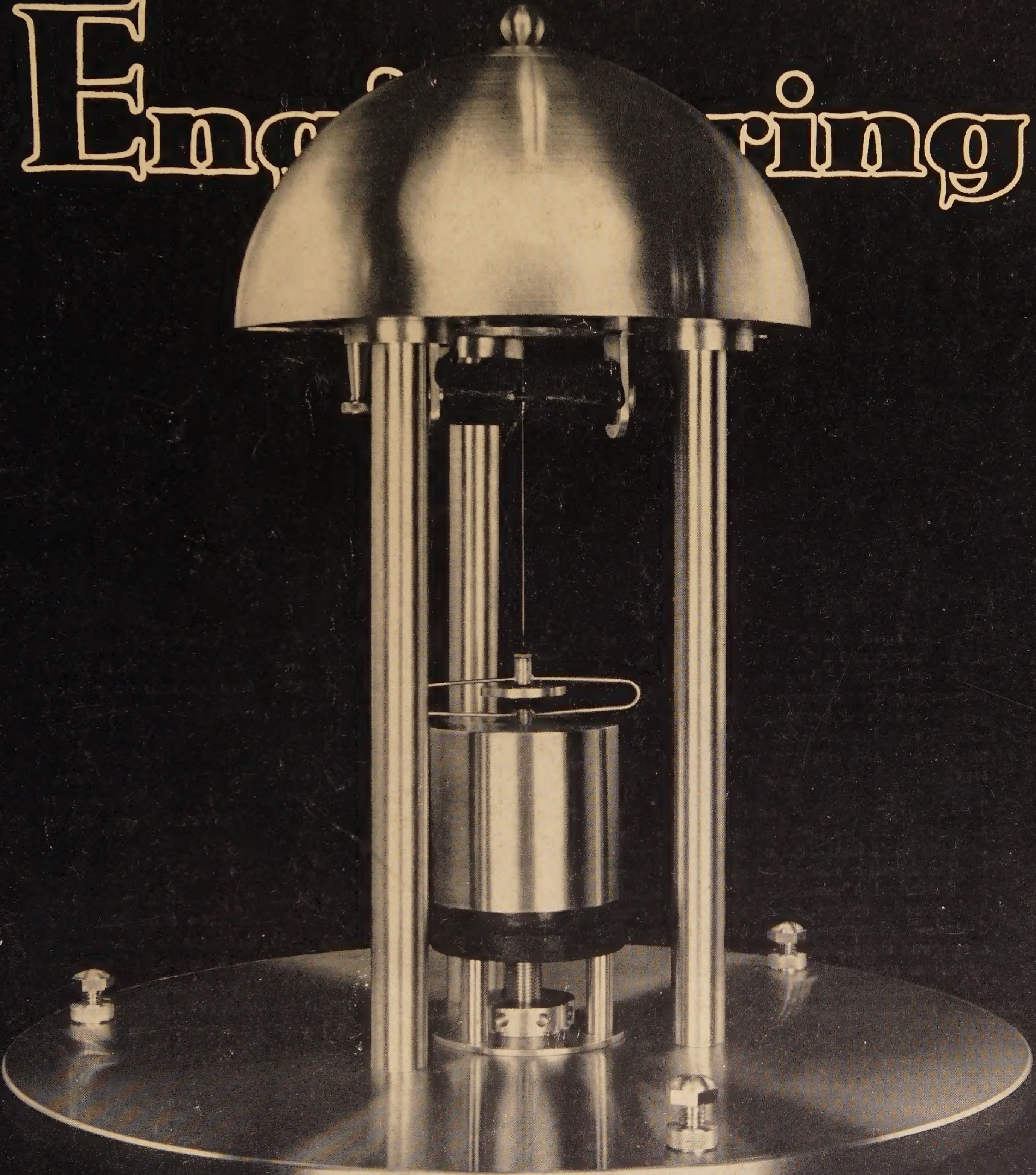
Electrical Engineering

March
1940



Published Monthly by the
American Institute of Electrical Engineers

Electrical Engineering

Registered U. S. Patent Office

for March 1940—

The Cover: A new instrument for time measurement uses as vibrator a wire kept in tension by a weight (see TRANSACTIONS pages 137–42).

Transactions Section *(Follows EE page 138; a preprint of pages 129–92 of the 1940 volume)*

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High Lights • •

Engineering Education. The engineer obviously must learn and know the technical matter that is unique to his profession; but if more than mediocrity is to be his reward, then he must develop himself in a broad manner so as to be able to solve problems by weaving together technical data with social, economic, and psychological factors, says one engineering-college dean, who describes the program established at his institution to provide young engineers with this type of training (*pages 119–22*).

Unsolved Transportation Problems. A review of some of the unsolved problems facing electrical engineers of the transportation industry points to the need for a research organization jointly supported by the operating companies. It is believed that such an organization could solve these problems in much the same way that the Presidents' Conference Committee solved the problem of the obsolete trolley car by preparing specifications for the PCC car (*pages 113–17*).

Hoover and Edison Medal Presentations. Featured at the recent winter convention was the joint presentation of the Hoover Medal to Gano Dunn (A'91, F'12) and the Edison Medal to Philip Torchio (A'95, F'12). Addresses of the medalists and of Past President John C. Parker (A'04, F'12) who introduced Doctor Dunn, and Ralph H. Tapscott (A'18, F'29) who introduced Mr. Torchio, are published in essentially full text (*pages 95–102*).

Radio Noise. Transient conditions in an electric circuit set up fields which cause radio noise; for the measurement of such effects a joint committee of EEI, NEMA, and RMA has recommended certain instrument characteristics, and practices in making measurements directly from apparatus or along lines, collecting data for establishing radio-noise standards, and determining broadcast field-strength levels (*Transactions pages 178–92*).

Distribution in Buildings. Electric distribution systems in buildings may be designed to have considerably greater capacity than is required by the initial connected load, without any appreciable increase in total cost; this reserve capacity will enable the system to handle the additional loads likely to develop after initial installation and may avoid costly replacements (*pages 104–06*).

Bridge Networks. Much technical literature has appeared on the subject of bridge networks, which are of many types and which are used for measurements of numerous electrical as well as nonelectrical quantities. Users of bridges, students, and others interested in the subject may find useful a brief classification of various bridges, with balance equations for each (*pages 108–13*).

Earnshaw's Theorem. A century ago Samuel Earnshaw formulated the theorem that "a charged body placed in a field of electric force cannot be in stable equilibrium." In this issue, a physicist offers additional support for this theorem and shows its relation to two types of stable free suspension using magnetic forces (*pages 118–19*).

Time Standard. Using a wire kept in tension by a weight as the vibrating element, a new device for use as a secondary time standard may have an error of less than one-tenth second per day under favorable conditions; the frequency may be varied over a moderate range with precise control (*Transactions pages 137–42*).

Testing Arresters. Distribution lightning arresters that are removed from service may be tested and rehabilitated for further use for between 5 and 15 per cent of the cost of new arresters in ratings from 3 to 15 kv, according to a survey of the practices of a number of operating companies (*Transactions pages 142–9*).

Voltage Regulator. Essentially perfect regulation may be maintained by modern direct-acting voltage regulators by utilizing an inherent nonlinear property of the resistance elements, careful balancing of electrical and spring torques at every point in the range, and use of a stabilizing transformer (*Transactions pages 149–57*).

Train Control. An automatic block signal system with no visible block signals is used to control the movement of trains operating with small headway on the San Francisco-Oakland Bay Bridge; electrical equipment was chosen throughout in preference to nonelectrical mechanical devices (*Transactions pages 158–64*).

Cable Sheath. Production of sound lead sheath throughout a length of cable requires complete union of the successive charges in the cylinder of the lead press and the removal of impurities in the lead. Both mechanical and chemical methods are used in a new technique (*Transactions pages 165–78*)

Radio-Frequency Phenomena. A correlation between high-voltage phenomena at radio frequencies and at power frequencies has been observed in that the gradients at which high-frequency breakdown occurs appear to follow the same laws as 60-cycle corona (*Transactions pages 129–37*).

Engineers as Arbitrators. "Engineers as a class might well prove a fertile field for recruiting a body of competent, intelligent individuals to serve industry and labor in a neutral capacity in the adjudication of their conflicts" (*pages 102–03*).

Winter Convention. The detailed report of the 1940 winter convention appears in the Institute Activities section (*Pages 126–9*). It includes reports of the meetings of the committees on Student Branches, Sections, electrochemistry and electrometallurgy, education, communications, and sound. The technical conferences on electronic devices, test code for synchronous machines, definitions, and sound are also reported.

Nominating Committee. Meeting during the winter convention, the national nominating committee presented its ticket of candidates for national Institute offices (*pages 129–30*). Biographies of the candidates appear in the Personals section (*pages 131–3*).

Board of Directors. Appointments, meetings, and other matters of interest were acted upon by the Institute's board of directors at its regular meeting held during the winter convention (*page 129*).

Letters to the Editor. "The Use of the Millibar for Weather Bureau Reports" and a method of "Obtaining Test Constants for Induction Motors" are dealt with this month in letters to the editor (*pages 124–5*).

Television Tube. To meet the requirements of television, a 20-kw tetrode has been developed for ultrahigh-frequency transmitters; its design presented special problems (*page 107*).

Coming Soon. Among special articles and technical papers now undergoing preparation for early publication are: a comprehensive article on the illumination at the New York World's Fair, with four-color illustrations; an article outlining trends in railroad motive power by Sidney Withington (F'24); an article reviewing the trends in the development of electrical apparatus for the generation, transmission, and distribution of electric energy by A. C. Monteith (A'25); a paper describing methods of controlling radio interference by C. V. Aggers (A'39); a paper on variable-voltage equipment for rotary oil-drilling rigs by E. H. Lamberger (A'27); a paper on the use of multiwinding transformers with synchronous condensers for system voltage regulation by H. P. St. Clair (M'29); a paper on the wave shape of 30- and 60-phase rectifier groups by O. K. Marti (F'39) and T. A. Taylor (M'36); a paper describing the Magne-Blast air circuit breaker for 5,000-volt service by E. W. Boehne (M'37) and L. J. Linde (A'39); a paper discussing arc-furnace loads on long transmission lines by T. G. LeClair (M'29); and a paper on the modernization of a transit system, with particular reference to the factors that determine the choice of vehicle, by G. L. Hoard (A'19).

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GANO DUNN
HOOVER MEDALIST

Hoover and Edison Medals Presented at Winter Convention

"Distinguished public service" and "meritorious achievement in electrical science, engineering, or arts" were recognized by the presentation of the Hoover and Edison medals, respectively, to Gano Dunn and Philip Torchio, Fellows of the AIEE.

PHILIP TORCHIO
EDISON MEDALIST

PRESENTATION CEREMONIES for both the Hoover Medal and the Edison Medal for 1939 were held January 24, 1940, during the recent AIEE winter convention in New York, N. Y. The Hoover Medal, joint award of the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, and AIEE, was conferred upon Gano Dunn (A'91, F'12, past president, Edison medalist) president of the J. G. White Engineering Corporation, New York, and of Cooper Union for the Advancement of Science and Art. Philip Torchio (A'95, F'12) retired vice-president, Consolidated Edison Company of New York, Inc., received the Edison Medal, highest honor of the AIEE, for "distinguished contributions to the art of central-station engineering and for achievement in the production, distribution, and utilization of electric energy."

Doctor Dunn's attainments were described by Past President John C. Parker (A'04, F'12) vice-president, Consolidated Edison Company. John V. W. Reynders, past president, AIME, and chairman of the Hoover Medal board of award, presented the medal to Doctor Dunn, with the citation, "Long honored by his fellow engineers for professional achievement, he has, beyond that, exemplified high civic purpose and a devotion to public service which have earned for him the Hoover Gold Medal for 1939."

The history of the Edison Medal was reviewed briefly by L. W. W. Morrow (A'13, F'25) chairman of the Edison Medal committee. The achievements of Medalist Torchio were described by R. H. Tapscott (A'18, F'29) president, Consolidated Edison Company of New York, Inc., and presentation of the Edison Medal was made by President F. Malcolm Farmer. The addresses of Doctor Parker, Mr. Tapscott, and the two medalists follow in essentially full text on this and succeeding pages.

Gano Dunn—1939 Hoover Medalist

JOHN C. PARKER Past President AIEE

From time immemorial it has been the custom of social groups to appraise their most distinguished members and in one way or another to declare to the world their appraisals. It is peculiarly fitting that in a period in which, with increasing emphasis, the engineering profession has been discussing the social status of the engineer, we should address ourselves to the granting of the Hoover Medal to one who, in the highest sense, represents the qualities held in esteem by his colleagues.

The granting of such honors fulfills a threefold function. In the first aspect it is a declaration to the recipient of the esteem in which he is held by his colleagues, then internally to the group it serves as a confession of its ideals, and last, but not least, it pronounces to the outside world those qualities of mind and of character which the group collectively most values and of which it deems the recipient to be a signal exemplar.

The medalist, Doctor Gano Dunn, has received so many and so notable honors that we can add but little to his fame by this most distinguished award; we can and do draw aside for a moment from our routine tasks to consider the qualities of one whom, without envy, each of us would strive humbly to emulate; we can, and do, by our act here this evening, declare to the lay world those qualities of person and those achievements in one of our members by which we would like the world to know our profession at its finest development.

We start with the conception of engineering as based on the physical and mathematical sciences. A kindly and tolerant predisposition toward science is not enough in a great engineer; he must have a profound understanding and a creative attitude toward the fundamental sciences in all their ramifications and in their applications as well.

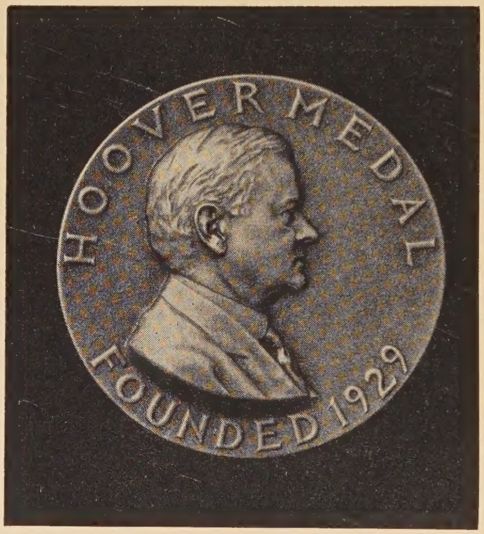
Our ideal engineer will not rest content with mere scientific exploration. He will be of a practical mind and will force his science realistically, through invention and design, to serve the purposes of men. This he will do in a practical world governed by economic law. He must be a realistic economist.

His engineering must be carried through, co-operatively with men of diverse minds and interests, for the service of the society of which he and his profession are components. This means that he must have broad and understanding social qualities. These qualities cannot be of the mind alone, nor can they stem merely from conscious policy. They must derive from the spirit of the man. His inflexible honesty can never become self-will; his clearest thinking will be adaptable; his contacts with men of lesser endowments will be modest and patient.

This ideal engineer, proud of the attainments of his profession, devoted to its fascinating technique and purposefully giving himself, co-operatively with other men, to a realization of that technique in and for the service of society, still will know that, important—essential—as it is, it is not all that there is in life. So he will devote himself to those good things outside his profession which make for a society so well rounded as to enable men of other interests the better to live their lives, and themselves, in their own preferred way, to be a part of the human family.

Because Gano Dunn has been to his fellow engineers an example of these qualities which in their full development can make our profession great, we join to affection a sense of deep obligation to him as our gentle and self-effacing standard bearer.

The board of award says, "The medal signalizes great unselfish nontechnical service by engineers to their fellowmen." While the emphasis is on the broader service, it is none the less on service rendered not in lieu of but above and beyond the full measure of engineering attainment. Implicitly, the latter is a primary, though not the ultimate criterion. There is no need here to review Doctor Dunn's scientific and professional attainments. Not only are these well within the view of his fellow engineers, but on the occasion of other honors that so deservedly have come to him they have been set forth in detail. On this occasion we concern ourselves with those things for which he is esteemed by his "fellow engineers for distinguished public service."



The Hoover Medal

Because Doctor Dunn has combined a great love and reverence for his profession with high vision of its social value, it was natural that he should seek to compel his corporate engagements to serve the broad ends of society, making of them something vastly greater than business enterprise. It is in this spirit that he has directed the activities of the great corporation of which he is chief executive into a diversity of services to the nation, to our neighboring republics, and on other continents.

It is not without significance as to the broadly human interests of this man that, as mentioned at the time of the conferring on him by the AIEE of the Edison Medal, service to the fine arts, as exemplified in the renovation and redecoration of the Metropolitan Opera House, was within the scope of his organization equally with the design and execution for our government of so various projects as nitrate plants, steam generating stations, and government aviation terminals.

More personally perhaps, but still within hailing distance of his engineering interests, Doctor Dunn has himself conceived many projects for broadening the service of science and technology to mankind. Equally he has been willing generously to participate in the work of others whenever worthily addressed to human betterment.

It was in character that he should take a large part in the organization of the Engineering Foundation of which he was the first chairman, and of the National Research Council of the National Academy of Sciences, of which he was chairman for five years in the late 20's. His presidency of the United Engineering Societies, of the AIEE, and of the New York Electrical Society were characterized by effective effort to make these organizations more fully serve humanity.

Going further afield, his chairmanship of the building committee of the National Academy of Sciences, his service as a member of the War Department Nitrate Commission and as chairman and disbursing officer of the special committee of the State, War, and Navy Departments on submarine cables, and as a member of the engineering committee of the Council of National Defense during the World War are typical of the way in which he has found a broad field for the devotion of engineering to the public welfare.

For many years he has been chairman of the visiting committee of the National Bureau of Standards, and in 1936 he represented the State Department on the executive committee of the World Power Conference. He serves the country as a member of the Patent Office advisory committee. Under presidential appointment, he served as a member of the Science Advisory Board. He is also a member of the business advisory council of the Department of Commerce.

No national boundaries limit Doctor Dunn's effort to make science and engineering serve mankind. As vice-president of the International Electrical Congress of Turin in 1911, as an officer of the International Electrical Congress in St. Louis, as official delegate of the United States Government to the Second Pan-American Scientific Congress and to the Third Pan-American Commercial Conference, he has reached beyond the boundaries of our land. Reciprocally at home he serves as honorary secretary for the United States of The Institution of Electrical Engineers of Great Britain.

This conception of social obligation, this high vision of his profession as a very human thing naturally find expression in fields removed from the merely professional. I mention in passing only a few.

Under the recent appointment of the President, he serves as a member of the President's committee on civil service improvement, and by Mayor La Guardia he was recently appointed consultant to the New York City Housing Authority.

I need not recite to you his services to education beyond mention of his trusteeships in Barnard College, in Columbia University, and his presidency of Cooper Union for the Advancement of Science and Art.

These few of his many services are presented not as a catalog but as a refreshment of your memories. All of you know the devoted and unsparing service which Doctor Dunn gives to any activity with which he becomes identified. The devotion, the work, the fine wisdom which he brings to bear on his every activity, in and of themselves, would be enough, but greater than these, I believe, is the quality of the man himself, a quality which enriches every phase of life in which he participates.

It is interesting to speculate as to the influences that have made our great men what they are. I suspect that no one, not even the man himself, can ever quite appraise the weight of heritage and environmental influence in the formation of character.

Why, under a given set of influences, one man becomes hard and inflexible and another gentle and tolerant, why one becomes soft and another firm, we probably never fully will understand, but knowing that some, like the medalist of this evening, have done so well for the world through themselves, we have no excuse but to make our own environments and our own opportunities serve in ourselves as he has done to make life better for our fellows.

Was it from his paternal grandfather, Nathaniel Dunn—"a passionately devoted scientist and inventor, college professor, poet and author"—was it from the circuit riders two and three generations back on the maternal side, that he derived his inspiration and guidance?

How much of human understanding and of kindliness was induced by the frustrations of his plan for his collegiate career and by the fact that his course in the College of the City of New York was supported by the modest work of a night telegraph operator? How much of kindness and direction in his living came from contact in the postgraduate school of electrical engineering at Columbia University with the late Francis B. Crocker and Michael I. Pupin? These things we do not know, nor do we know why this man, from whatsoever sources, derived a sense of obligation, a kindliness, a patience with ordinary men, a nice regard for their rights and feelings, an integrity, and a sense of fairness which are the stigmata of the gentleman.

An old friend of Doctor Dunn, himself a fine embodiment of those qualities which make best for human service, Doctor Frank B. Jewett, recently wrote me of him: "He is patently honest and fair and without that pride of opinion which causes so many men to adhere to a false opinion merely because one has been expressed without full knowledge of the facts. . . Never once have I seen evidence that this point of view was in any way warped by the slightest tinge of mean or petty self-interest, either personal or in behalf of the group he represented. Always he has seemed to keep clearly in mind the necessity of reaching a final conclusion which incorporated fully the fundamental best interests of every one."

On behalf of the board of award consisting of representatives of the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, and American Institute of Electrical Engineers, the Hoover Medal is being awarded to Doctor Dunn.

This is a noble award and I know how profoundly in his great gentleness of soul he will appreciate the approbation of his fellow engineers. Greater than this award and the other notable honors that have come to him, greater than the recognitions through appointments to public service, greater than the honorary degrees that have been conferred on him by distinguished institutions of learning, he wears the ornaments of mind and character not as external habiliments put on to be seen but as the full flower of an inner spirit by which we would that men might always know the engineer.

Public Service

GANO DUNN, Past President AIEE

Some of the greatest controversies of today revolve around the question—what is public service and how should it be performed? There are those who regard it primarily as the service a government renders to its people, and there are those with a broader view who regard it as service rendered to the people, whether by government or by private agencies.

The public service rendered by government starts from a minimum under the old Jeffersonian ideal that that people is governed best which is governed least, and ranges through intermediate values to the other extreme represented by the totalitarian governments of Europe with a climax in Russia, where few of the activities of life escape government intrusion.

But I am not attempting a discussion of the relative merits of socialism, which, in the language of Doctor Nicholas Murray Butler, would wreck the efficiency of society in order to redistribute its discontent. Nor am I here eulogizing our own representative democracy based on the consent of the governed, with the government's power strictly limited by a Constitution and a Bill of Rights.

I do mean to point out that in our democracy the volume of public service rendered by private agencies is vastly greater than the volume rendered by government. The corner grocer who for our convenience and his own support provides a stock of food is rendering a public service, as is also the great insurance company which takes our savings and cares for the loved ones we leave behind us. These services are no less public services than are those of the post office, for instance. In fact, the whole realm of commerce and the arts, the ministrations of the professions and the church, and by far the major part of all the activities of our daily lives which the division of labor has assigned to us as our share of the privilege of living constitute public service rendered by private agency.

Although the aggregate of government public service is vastly less than that of private public service, the units through which government service operates are usually larger than the units of private public service,

notwithstanding the great size of certain private corporations which operate on a huge scale in industrial, financial, charitable, and educational fields.

Some of the most acute political issues of today in this country are joined over the question whether government public service is more efficient than private public service, and whether certain public services now rendered by private agency should be transferred to government.

If we analyze the Jeffersonian dictum that that government is best which governs least, we shall see that it means that the happiness of the people is best secured where there is a minimum of that kind of public service which is characterized by authority and force of law, and a maximum of that kind which, although regulated by government, is left to the initiative and internal administration of private agencies. Applying this criterion to the nations of the world, we shall not have much difficulty in discerning where happiness is at a maximum and at a minimum.

In our ordinary conceptions, the fact that all government activity and the major part of all private activity in public service is not prominent in our minds when we use the term public service, because public service of the kind that government employees render and a large part of that which the rest of society renders is balanced and paid for by economic compensation. It is the means by which we earn our living, and for earning one's living one should receive no more credit than that which goes to the performance of appropriate duty to the conditions under which we earn it.

Public service, as the term is usually used and as I shall use it hereafter, has come to have a more special meaning, which is the meaning given to it in connection with the Hoover Medal. It is applied to the service of those men and women who render to the public a service over and beyond that for which they are paid, a service which they render on account of love of their fellow men, and the satisfactions that come from doing something well, for the love of doing it rather than for the pecuniary reward it brings.

One has only to look around him to find public service of this kind on every hand, both in and outside of the government, to an extent that evokes the profoundest admiration, and re-establishes a sometimes faltering confidence in the capacity of human beings to live for unselfish ideals.

There is a complaint among engineers that their status as constituting a profession is not adequately recognized by society in general, and that their participation in public service in the special meaning of the term is not large relative to their numbers, nor in proportion to the participation of merchants, bankers, lawyers, doctors, and other individuals.

In the early days this used to be true, but I think the public service of engineers is now larger than they realize, both in the field of their technical services and in the broader fields of human relations outside of these. The background of an engineering training and equipment enables a valuable approach to other types of problems, which causes engineers to be drawn into civic, educational, and other activities outside of engineering work.

It is certainly a fact that engineers universally recognize the honor of public service and long to increase their own contribution to it. If they did not always feel this way, it is because the astonishing multiplication of great scientific discoveries and their economic application to the purposes of civilization, which is the field of the engineer, have in the past so absorbed and enchained engineers and given them such satisfactions and pecuniary rewards within their own profession, that neither in the processes of their education nor in the exercise of their tastes did they see the importance nor realize the joy and advantage of devoting to their relation to society as a whole more than a fraction of the attention which they devoted to their own fascinating art.

But all this has been different in recent years. As a result of growing recognition on the part of leaders in engineering education, the great engineering schools have, at the expense of diminished technical specialization, enlarged those areas in the education of engineers which tend to equip them for more useful and satisfactory places alongside of other men, not only in their own technical fields, but in the fields outside of them, into which engineers are more and more drawn.

The establishment of departments of humanities in our engineering schools, where history, languages, and the social sciences are now regarded as part of an engineering education, has been universally welcomed by engineers, and in no case that has come to my attention has the movement in this direction been reversed.

The very existence of the Hoover Medal "for distinguished public service", founded by Conrad Lauer and instituted by the four great representative national engineering societies, is an indication of the extent of the appraisal by the engineering profession as a whole of the high privilege it is for an engineer to contribute beyond as well as within the activities of his profession voluntarily to the service of the public, in emulation of such service by Herbert Hoover, the Medal's great exemplar, by Ambrose Swasey who founded the Engineering Foundation, and by John F. Stevens who saved millions of lives in Siberia.

The honor of this medal and the encomiums that have been heaped upon me I do not deserve, because of the little that I have accomplished in voluntary public service. But I have had a joy in laboring in that vineyard which nothing can express. I believe that the large number of engineers now similarly experiencing the joys of voluntary public service will increase rapidly, as the training and ambitions of engineers more and more make them available, and as the community comes to recognize in the engineering profession a vast untapped reservoir for public service.

Through such service, as well as through the practice of their profession, engineers will increasingly come to win their spurs and the honored place in the community along with other men, which they are now increasingly eager to fill.

In connection with such voluntary public service, it should be pointed out that it is not always the engineer who determines whether he shall take part in it. It is rather the community which adjudges his personality and quali-

fications, and invites him in if it feels he is competent.

More is necessary on the part of the engineer than a desire for public service. He may have this to a large degree and yet for lack of an adequate culture or the qualities of a judicial temperament, or for the lack of tact, he may remain uninvited.

A bar which also frequently prevents public service on the part of engineers otherwise well qualified is the peripatetic nature of their calling in some of its branches. The lot of the civil engineer is largely cast far from home, to the detriment of roots which other types of engineers are more likely to strike into the soil of their community, with public service as one of the fruits.

Engineers are not all of one mold, and just as poets are born and not made, so are great inventors and similarly great engineers. There are engineers with gifts for the conception of design and others with gifts for force and order in administration, some with minds for mathematics, and others intuitive to the geometric distribution of material masses. While they all have a common characteristic, in that they apply the scientific method of thought to whatever their problem may be, their personalities and qualities are so varied that generalizations about them as a class are not reliable. But in common with the great unifying principle of the scientific method of thought which binds them together, they have to a remarkable extent the endowment of another great gift, a love of truth, which springs from their contact with the laws of nature and is an outgrowth of the tastes which led them to become engineers.

Society welcomes such equipment, and as the march of scientific discoveries continues and national life becomes more complex, there is no doubt in my mind that the future holds wider open than ever to engineers the high honor of public service.

Philip Torchio—1939 Edison Medalist

RALPH H. TAPSCOTT, Fellow AIEE

Quite aside from the intrinsic fitness of the medalist, there are associated reasons why this year's Edison Medal award is particularly appropriate. The medalist has spent the greater part of his life actively in the employment of the company which derives from Mr. Edison's initial electricity supply undertaking. His earlier years were spent in the vicinity of and his technical education was received in the town of a pioneer development of Mr. Edison's system of generation and distribution. For many years he was a colleague of the 1923 Edison medalist, the late John W. Lieb, a former President of the Institute. In a very real sense it must be said of him that his lifetime was devoted to the realization, perfecting, and adapting to changing conditions of the work initiated by the great pioneer inventor and engineer whose work and memory this medal commemorates.

In the United States, in which the electric arts have so brilliantly and so extensively been developed, we are likely to forget how much of their origins are in the older world. There is for us electrical engineers a peculiar tie between the home of the medalist's maturity and his native country. As we have a precious heritage in the work of Galvani and Ferraris; as we have drawn from the ceramic industries of Italy; as we find ourselves honored to number among our members the Milanese Semenza, Pirelli, and Emanueli, whose work has enriched American engineering practice; as our profession further has been strengthened by the migration to our shores of eminent engineers and inventors like Marconi and Faccioli, so we have a further debt to that ancient but vital land in the work here of her son, Philip Torchio.

Forty-five years ago this month, he became identified with the light and power industry here in New York City.

It is impossible for most of us to visualize the real condition of the light and power industry of the early 90's. Certainly we know it was in its infancy; its tools had not been developed; there were many widely differing opinions as to its possibilities. Probably more time and thought had been devoted to the use of electricity as a convenience than to the economics of the industry as it exists today. Without belittling any of the discoveries and experiments at that time, let us say that generation and distribution were largely direct current; load was not only growing at a rapid pace but the requirements of distribution distances already had exceeded the limits of this method of generation and distribution.

That was about the state of the industry when Philip Torchio arrived from Vercana, Italy, in 1893 after his graduation from the University of Pavia and the Royal Polytechnic of Milan. First entering the employ of the Sprague Electric Elevator Company, he became associated with the Electric Illuminating Company of New York, one of the forerunners of the Consolidated Edison Company, in 1895. He was not alone an inventor but an engineer and an economist who took up the task of preparing the industry for its future growth. A-c generation and transmission were becoming the necessities of the business. The few small d-c generating stations in New York City had to be replaced by an a-c station with its transmission to substations for conversion of direct current throughout the city. It was through his analysis and co-operation with the manufacturers that it was possible to maintain underground transmission cables operating at 6,600 volts, and 25 years later these same cables were satisfactorily operated at 11,000 volts; but the continuity of the new system of generation and conversion was not as satisfactory as the direct use of d-c generation, and stand-by storage batteries became a necessity. Here again it was through Torchio's analysis that the present type of low internal resistance storage batteries, with the possibility of a high rate of discharge with a very low voltage drop, came into being.

But let us look for a minute at some of the controversial questions which were so rampant in those days. All of you know the difference of opinion which existed between the d-c and a-c proponents for normal distribution purposes. As alternating current became the standard for transmission systems, the question of frequency was the topic of the day. Should there be two frequencies—one

for conversion for d-c distribution and railway electrification, another for general commercial and residential use? Or should there be a compromise standard for the country to serve both purposes? In those days, systems were sprouting up at all sorts of frequencies—25, 40, 50, 60, and 125 cycles. Abroad, for successful railway purposes, the frequencies were even lower. In America, railway systems were generating at 25 cycles, either for single-phase use or for conversion to 600 volts; and although they were growing faster than the light and power companies, Torchio early foresaw the time when the operation of these two projects would be merged, and, again by his analysis of the existing conditions and the future, determined upon the 25-cycle system for all synchronous conversion purposes, either Edison direct current or railway use, and a 60-cycle frequency for those systems serving normal commercial and residential uses. As we look back, we realize that had a compromise frequency of say 40 cycles been adopted for the metropolitan territory, the necessary change-over to today's standard would have been a serious economic waste.

As the capacity of the systems grew, the problems of short-circuit currents assumed increasing importance. Torchio was among the first to adopt the use of reactance coils and to improve their mechanical design; but he also developed a fault detector and later a bus protector to limit further the effect on a system of a short circuit or ground on an individual feeder.

He has been granted patents on reactors, circuit breakers, fault detectors, protective devices, cable insulating methods, and cable joints; but the system developments of the past 40-odd years have been due more to his insistence and co-operation with manufacturers on the improvement of their protectors, their cable, and their large generators than upon the individual patents granted in his name.

These are a few of the objective achievements of the medalist. For us who are gathered together here tonight to do honor to him, the record is something more than the things he has done, however excellent they may be. The real import of the man and of his career lies in the personal qualities that led to his performance. Other men with equally good preparation entered the industry in the early years of the last decade of the last century. Some of them have left their mark on engineering development. Others have been content to accept what they found and to let natural growth take its course. Torchio has never been gaited that way. There is in his make-up no such thing as "good enough." Of himself and of his work he has demanded not only a high level of attainment, but always a higher and higher level. He has known how to set standards of perfection and then has been realist enough to strive in a practical way for a rational approach to those standards. It has not been enough for him to visualize an ideal, but rather with a burning enthusiasm, interestingly in the Edison tradition, he has ever striven toward it.

The Edison Medal

Often the absolute perfectionist, realizing the impossibility of ideal attainment, gives up and accomplishes nothing. Not so our medalist. The fact that the full standard of perfection is unattainable is to him a challenge to come as near to that as is feasible.

Nor has he been content roughly to outline his standards in broad general strokes. Rather he has insisted that no detail, so long as it is essential, is too unimportant to demand the best of thought and of performance. In some men this meticulousness can degenerate into mere fussiness. In all his operations, Torchio has had a nice sense of balance between those details, the soundness of which was essential to large objectives, and those attractive but dispensable ones, the overprosecution of which might divert from the end sought to be attained.

I have said that of himself he has always demanded a higher and higher level of attainment. Many of us, most of us perhaps, having done somewhat well in bringing forward our work, remain content with what has been achieved. To Torchio a high level of pioneering accomplishment has always served as a stimulus to push forward the frontiers which he himself has established. This is rather clearly revealed in the way in which, by progressive steps through his years of service with his company's system, he has sought every opportunity consistently with dependable service and sound economics further to advance the level of transmission voltages, finally finding expression in the introduction into American practice of 132-kv underground transmission of a character which has given excellent confirmation of his sound operating judgment and fine administration of technical detail.

Torchio is no narrow specialist. While his work has best been known because of his contributions to the transmission and distribution art, particularly with reference to underground circuit construction, the few specific references that already have been made give illustration of a breadth of interest more fully confirmed by the list of titles of his contributions to the literature and even better recognized by his immediate associates. From system planning and frequency selection and interrelation of diverse types of prime movers, through switchgear, transmission and transformation, distribution and metering, he has extended his interests and his creative contributions to the apparatus of utilization, never, for all of the diversity of his interests, abating from the exacting standards of thoroughness that he established for himself.

Always he has recognized engineering as an adjunct of economics, and so, in forming and giving direction to his technical work, it was but natural that he developed a

vital interest in that economic balance without which engineering can become mere technique.

Realizing that his engineering and economics exist for execution by human beings in the service of the community, he moves on into a wider range of interests.

He was the originator of a group insurance plan for corporations which he submitted to the large insurance companies in 1910 and which has become quite universally adopted since that time.

His keen, observing mind could not long remain indifferent to the fact that many a poor and unsophisticated immigrant to this country became the victim of exploitation. It was in character that he sought to relieve this among people coming from his native country and that he sought to do it through normal and realistic channels, and so he made himself responsible for the organization of the Bank of Naples Trust Company of New York, of which he is now president, director, and chairman of the board.

During the World War he acted as consultant to the Navy Department in the design of electric cables on shipboard.

His sense of responsibility to the community appears again in his service for several years as a trustee of his home town of Bronxville, culminating in a term of service as mayor of the town.

I probably have made a poor presentation of the ways in which the industry has benefited from Torchio's life, but I am sure you will all agree that he is a most worthy exponent of the meritorious achievement for which the Edison Medal was founded.

It is partially because he has been my teacher and my guide for 25 years that I consider it a great honor and privilege to be allowed to present Philip Torchio on behalf of the Edison Medal committee.

An Engineer in the Power Industry

PHILIP TORCHIO, Fellow AIEE

When I first went to the New York Edison Company in 1895, I became very much interested in the study of all factors that influence the cost of production. As an illustration of such interest I have, among my papers, a duration curve entitled "Curve Showing Number of Hours During Which the Load on Duane Street Station Did Not Exceed a Given Percentage of the Annual Maximum Load—Year 1895." In a marginal tabulation are given, in percentages of the annual maximum, the hours' use of the station under different loads. The load was greater than 70 per cent of the maximum for less than 1 per cent of the time. For nearly 50 per cent of the time the load did not exceed $6^1/_2$ per cent of the maximum. Accompanying the curve follows a report of three weeks' tests to determine the cost of operation for different watches, and the remark is made that by increasing by 50 per cent the output of the minimum watches, the increased output could be produced at one-fifth of the average pounds of coal per kilowatt-hour consumed during the minimum-load watch. I do not believe that a duration curve of the operation of a central station had ever been assembled before. From the broad economic point of view its importance is just as great today as it was in 1895. Upon its underlying principles has been built the structure of efficient operation of plant, economic utilization of investments, and promotional rate schedules.

In a lighter vein, while engaged in these efficiency tests, I made by the Orsat method a Btu test of some samples of different coals, but when I submitted them to the purchasing agent I was discouraged from pursuing such investigation, because, he said, the heating power stored in the coal millions of years ago would not be changed by any amount of testing.

With the steady growth of demand for increased services developed the desirability of determining the most economical cross section of copper wires used in our distributing mains and feeders. The subject necessitated extensive studies which were made available in 1900 to the Association of Edison Companies. As a side line an interesting analysis, published in the 1901 AIEE TRANSACTIONS, gave the large savings in investments that could be made by using double voltage lamps, as was then the general practice, and still is, in England, and later in some other countries. Unfortunately, with carbon filaments, then in use, the double voltage lamps required, for same life, considerably greater wattage per candle power, which would have offset most of the savings in plant investment. With metallic-filament lamps such a drawback is no longer present, but the cost of a change is now prohibitive. We miss the advantages of higher distribution voltages enjoyed in other countries whenever devices of heavy power consumption, as for instance electric ranges and space heaters, are to be connected.

While pursuing these practical studies of economics in transmission of electricity in 1901, I was impressed by the lively electrical charge shown by the rubber-insulated braided cables used to wire the different compartments of the high-voltage switchboards. It seemed to me that this process of charging insulation also might possibly involve some loss of power. Accordingly we arranged to measure the suspected losses on two three-phase feeders, one insulated with rubber and one with paper. These were the first measurements of dielectric losses, which in later years became the bases of reference for studying all improvements in the art of cable manufacture and operation.

Incidentally, this investigation, and the related study of the laws that govern the distribution of potential in a medium made up of different strata each having different inductive capacities, have been of great help in many directions, but most effectively in the analysis of high-voltage system disturbances and insulation breakdowns. Of these you will find a graphic illustration in the 1913 TRANSACTIONS—a set of photographs showing step by step the deterioration of the rubber insulation in a cable under test, and the final breakdown. A few years ago I asked a friend to make a moving picture of the photographs but he could not succeed in getting satisfactory results.

Speaking of pictures, the oscillograph has been a godsend

to the electrical industry. To study the sources of the apparently enormous currents in high-voltage disturbances, in 1909 short-circuit oscillograph tests were made, in co-operation with the manufacturer, on one of our large turbine units. The results indicated the desirability of providing means of reducing the amount of generator short-circuit currents. In a certain manner the development of a system of devices that would automatically keep the current within the safe limits of each particular circuit appealed to me as vital to the maintenance of continuity of service on the system. This policy of continuity of service had developed under the inspiration of the early Edison pride in keeping the service going under all possible difficulties, of which policy John W. Lieb, one of the early Edison Medalists, was the highest exponent in our company. It was therefore natural that the company should be one of the leaders in the design and use of reactance coils for the protection of its high-voltage services.

Following the urge for a close knowledge of the fundamentals of the industry, throughout the early period of my association with the company I made it a point of duty to inspect and closely analyze the circumstances of all breakdowns on the high-voltage system. The information so obtained was of inestimable value in suggesting improvements on the system in all its ramifications. Some of these studies assumed great importance in enabling us to point out to manufacturers ways of making considerable improvements in high-voltage circuit breakers, large turbogenerators, and high-voltage cables.

Of equally inestimable value have been the studies of engineering economics in aiding the company toward a combined technical and commercial progress.

In the larger field of national power economics the subject is so broad that one is apt to become stalled in the study of a phase of the problem and lose the perspective of the whole. I was attracted to this subject during the last war when the problem of power and coal supply to the nation became the subject of concern to the government. For my personal information I made an extensive study which was later reproduced in the 1920 Transactions. One of the astonishing results therein given is that, for 1915, if the nation had used all the potential hydro power which is available east of the Rockies it would have supplied only eight per cent of the total energy for all its heating and power requirements. Many times the equivalent of that total amount of hydro energy could be secured by changing the existing inefficient methods of utilizing the fuels, provided the cost of the changes would not stand in the way.

In concluding, what I wish to convey is that my close and intimate association with the growth of the industry, and the constant love for its better knowledge, have been the mainsprings of what you may consider a possible contribution to its development. Such results could not have been accomplished without the progressive policies of the company and the invaluable co-operation of the men associated with me in the work. Looking forward I firmly believe that the power industry is still in the stage of youthful expansion, and holds out its glowing promise to all young engineers of good will.

Engineers as Arbitrators

Engineers are urged to apply themselves constructively to the problem of adjudication of disputes between management and labor

IF WE HAD no other index of the importance of labor in the economic life of the United States than the extent to which the newspapers daily deal with the subject, we would still be right in concluding that the problems associated with labor relations in industry are of grave significance and warrant the most earnest consideration by the constructively minded and thinking people of the nation. Since, however, the labor question is deeply involved in those processes with which engineers as a class are closely associated, any observations emphasizing the importance of labor in industry to them should not be necessary. I can think of no professional class in society that really comes into closer contact with labor problems at the source than do the engineers. It seems to me very appropriate, therefore, for our engineers to tarry occasionally in the pursuit of their careers and determine for themselves whether they might not be missing an opportunity to make a constructive contribution to the more orderly solution of the human problems incident to the conduct of industry and, if so, what the nature of that contribution might be.

I shall sketch very briefly the situation which, as I see it, opens the door for the qualified engineer to play his part in the more orderly development of labor relations, and second, give some idea, gleaned from my experience and observations, as to what an engineer is up against who might aspire to help adjust or sit in judgment of specific issues growing out of the labor problem.

The basic objective of many declarations of public

Excerpts from an address of the same title delivered by Otto S. Beyer, chairman, National Mediation Board, at the 20th annual assembly of American Engineering Council, Washington, D. C., January 12, 1940.

policy and related federal and state laws, such, for example, as the Norris-La Guardia Anti-Injunction Act, the National Labor Relations Act, the Railway Labor Act, and Title X of the Merchant Marine Act, is to further the process of collective bargaining in industry as a means toward establishing the so-called labor standards of industry, that is, the rates of pay, hours, and working conditions of labor.

Collective bargaining has come to mean: first, the organization of employees into so-called labor unions of their own choosing; second, the acceptance by management of these unions as speaking for the employees in all matters of vital concern to them; third, the negotiation particularly of labor agreements between management and these unions defining rates of pay, hours, rules, and working conditions; and fourth, the provision of methods for assuring that the terms of such labor agreements are effectively observed.

Where proper advantage is taken of the opportunities provided by law and otherwise to negotiate labor agreements under the auspices of collective bargaining, three processes are utilized, either separately or in serial combination, to achieve the objectives sought. The first process is that of direct negotiation between representatives of management and of employees. The second process is that of mediation, and the third, arbitration.

Thus, where collective bargaining is employed for the purposes of establishing the labor standards of industry, the services of four types of individuals may be utilized in connection with one or another phase of the process. The first type is the negotiator. He may represent either the employer or the employees. In either case, he must be experienced and competent, and certainly he must know a great deal about the game in which he is required to play so important a part. The second type is that of the mediator, sometimes called conciliator. He, too, should have an intelligent grasp of the problems of industry and labor, be able to talk the language of the representatives to a given labor negotiation, and be endowed with the faculty of inspiring confidence as an intermediary. The third and fourth types, namely, arbitrators and referees or impartial chairmen, must be essentially judicial in their approach to the matters in respect of which they are called upon to sit in judgment. Here again, an adequate background of the processes and economics of industry, together with a faculty to analyze testimony and weigh arguments, is important in persons selected for such assignments.

Except for the first type of individual, namely, the negotiators serving as the direct representatives of the parties immediately concerned in the making of labor agreements, the other three types, in addition to expert knowledge and comprehension of the problems of labor and industry, must be strictly impartial as between the interests involved in the proceedings. That the engineer is equipped by education, training, and experience to serve industry on the technical side superficially argues that he also ought to be able effectively to appraise and understand the economic and human phases of the industrial process. In all events, the engineer is exposed to these sides day by day no less than he is exposed to the technical side of industry, and so, if sufficiently curious and imaginative, ought to generate as healthy an understanding and appreciation of these other sides as he has of the technical problems of his profession. The situation, however, as regards the engineer is not so simple as this.

The labor problem is essentially a problem of the distribution of the proceeds of industry. The worker, under our present economic system, receives his share of the wealth created by production chiefly through his pay envelope. The significance of this fact has never been more clearly presented than by the so-called Lane Commission in its report to the Director General of Railroads, dated April 30, 1918, in which it observed:

> "To ask a man, 'What wages should you in justice receive?' is to ask perhaps the profoundest of all human questions. He is at once compelled to an appraisement of his own contribution to the general good. He must look not selfishly on his own material needs, but take a far view of the needs of those dependent upon him. He must go into the whole involved problem of his relationship with his fellows, and to answer the question aright he must in the end come to a judgment which will be nothing less than a determination of what policy or plan of wage adjustment will make for the permanent well-being of the State."

Concrete questions, difficulties, disputes, and the like in the field of labor relations are all variants, in one form or another, of the basic issue posed in the foregoing observations of the Lane Commission. The reference of issues arising between labor and management either to mediators, arbitrators, or referees for their orderly adjudication is very recent in society. Ordinary difficulties and problems arising between men in society have been adjudicated for thousands of years by courts of law and justice, and a whole body of practical and expert personnel in the form of lawyers and judges has come into being to deal with these matters. There have been no corresponding developments as yet, however, either as far as laws or as far as personnel and agencies are concerned, working to settle the so-called labor problems of society in the same orderly ways that have been devised to settle other types of differences between men in society. Yet the situations out of which labor problems and related difficulties grow are more fundamental to society than many of the usual legal questions presented to our courts for adjudication.

Rapid progress, however, is being made in formulating more scientific and orderly methods for dealing with the labor problems of industry. In so far as the engineering profession can see its way clear to take cognizance of this phenomenon and realize that engineers as a class might well prove a fertile field for recruiting a body of competent, intelligent individuals to serve industry and labor in a neutral capacity in the adjudication of their conflicts, the profession would greatly increase its usefulness to society. What it takes to bring this about is another subject well worthy of very serious consideration, and I trust the engineers will apply themselves constructively to this problem. If they do and make available to us who are continuously on the lookout for broadminded, intelligent, socially conscious, and technically well-informed and equipped individuals, it will be possible to provide them with ample opportunity to employ their talents.

Electric Distribution Systems in Buildings

LOUIS W. MOXEY, 3rd
ASSOCIATE AIEE

Increased intensity of illumination and the upward trend in industrial power requirements have loaded the electric distribution systems in many buildings beyond their rated capacities, requiring many extensive rewiring jobs that could have been avoided by the provision of adequate reserve capacity in the original installation. It is pointed out here that even though no material increase in load results after a number of years, a system having more than the capacity required by code rules is economical.

DESIGN of distribution systems within buildings has generally been based upon the National Electrical Code requirements for conductor capacities, with various allowances for voltage losses. Excess capacity, for future increases in load, has been limited to buildings where some future expansion is contemplated or expected at the time the system is installed. Where no increase in load is expected, the first cost is the principal factor that controls the design and prevents excess capacity from being installed. Little, if any, consideration is given to the cost of energy losses. Economy of operation is based upon the sum of capital costs and energy losses. Several of the factors affecting these costs are considered herein, principally system characteristics, voltage regulation, and conductor capacity.

System Characteristics

Of the many variables affecting the cost of distribution systems, the system characteristics can be considered only where the utility service to a building is at primary voltage and where there is a choice of several systems, such as single phase, three wire; two phase, five wire; three phase, three wire; or three phase, four wire for lighting; and two phase, four wire; or three phase, three wire for power.

An approximation of the relative costs of these various systems is shown in table I. These figures are for the conduit, wire, and control switches for feeders, and are based upon equal losses and voltage regulation and unity power factor. They indicate that the three-phase four-wire system for lighting and the three-phase three-wire system for power cost less than single-phase or two-phase systems. However, transformer installations for three-phase distribution systems will be found to cost more than for two-phase systems, so that for a complete system there will be less difference in cost than these figures indicate.

Voltage Regulation

In order to determine the voltage regulation requirements for distribution systems the effect of variations in voltage on the different types of loads must be considered.

The characteristics of Mazda incandescent lamps are such that it is desirable to keep the voltage near the rating of the lamp. The lumen output varies approximately as the cube of the voltage, whereas the life varies inversely as the 13th power of the voltage; consequently as the voltage is lowered the life becomes materially longer and the light output is decreased, and vice versa.

A ten-per cent difference in intensity of illumination is just noticeable when it is caused by a sudden fluctuation in voltage, such as results from materially increasing or decreasing the load on a circuit. Larger variations in intensity are much more noticeable and often annoying. A reduction of ten per cent in intensity, however, does not noticeably affect visibility or adequacy of illumination. It would appear that a ten-per cent variation in light output is a reasonable value to use for the determination of voltage regulation. This variation of light from Mazda "C" lamps results from about a three-per cent variation in voltage.

If the cost of operation per unit of light received, that is, energy and lamp renewals divided by lumens output, is plotted against voltage it will be found that the minimum cost is near rated voltage. This is illustrated in figure 1 on the basis of 100- to 500-watt lamps and two cents per kilowatt-hour for energy, in which case the cost for light is minimum at approximately 105 per cent of the rated voltage of the lamp. Obviously, the cost of energy determines the point at which the lowest cost for light is obtained, but near this point within about two per cent difference in voltage above or below it there is little difference in cost. In order to keep within this area, the regulation therefore should be not greater than four per cent.

Induction motors do not require such close voltage regu-

Table I. Approximate Relative Costs of Various Distribution Systems

Unity Power Factor, Equal Losses, and Equal Voltage Regulation

Single phase, three wire, 230/115 volts	1.00
Two phase, five wire, 230/115 volts	0.95
Three phase, four wire, 200/115 volts	0.90
Three phase, three wire, 115 volts	1.75
Two phase, four wire, 230 volts	0.80
Three phase, three wire, 230 volts	0.65
Two phase, four wire, 460 volts	0.45
Three phase, three wire, 460 volts	0.40

A local Section prize paper presented at a meeting of the AIEE Philadelphia Section, May 8, 1939.

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lation. Recommendations of the National Electrical Manufacturers Association permit ten-per cent variation above or below rated voltage so far as temperature conditions are concerned. There are, of course, variations in torque and slip which may become important factors in certain applications. Where the service voltage is 230 volts, approximately five-per cent line drop will produce rated voltage at 220-volt motor terminals. If the service voltage is 208 volts, five-per cent drop is obviously the maximum permissible where 220-volt motors are used. In the great majority of installations, however, the distance from the service point to the motors is not so great as to cause the drop to exceed five per cent at full load, if the requirements of the National Electrical Code are followed in determining conductor sizes. Furthermore, the demand for the majority of motor loads is of the order of half the connected load. The proper operating conditions in such instances can be obtained without consideration of voltage regulation.

Distribution Economics

The effect of voltage regulation and conductor capacity on annual operating costs is indicated in figures 2 and 3. Figure 2 shows how the energy losses and capital charges for a lighting distribution system vary with different values of voltage regulation. Obviously, the cost of energy, lengths of circuits, average demand in relation to connected load, and hours of use are all variables that enter into the picture. These curves are intended to represent an average condition and show that there is a low point for the total operating cost between two- and four-per cent voltage regulation. Unless circuit lengths are very short, two-per cent regulation appears to be the minimum desirable from the standpoint of total operating costs. These figures, it should be noted, are for the complete distribution system including branches and feeders, and are based upon connected loads, so far as calculation of the voltage drop is concerned, but upon 70 per cent of the connected load for determination of losses.

For induction-motor loads the voltage regulation will not vary in proportion to the losses, because of the effect of power factor and line reactance, so a different basis of comparison is necessary. The costs in figure 3, therefore, are plotted against the capacity of the conductors, based upon the 1937 National Electrical Code. These curves

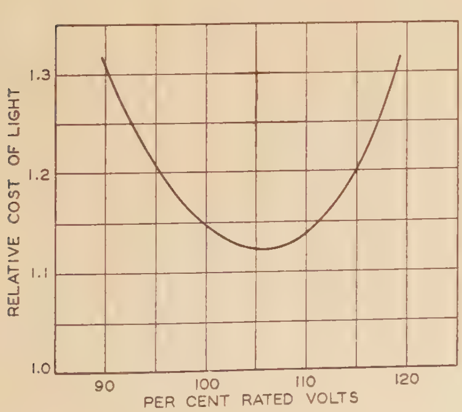
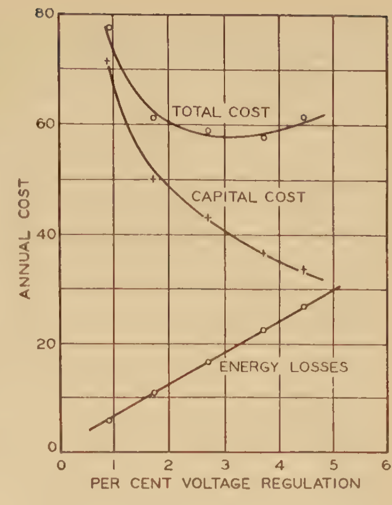


Figure 1. Variation with voltage of cost of lamp renewals and energy, per unit of light; cost of energy assumed to be two cents per kilowatt-hour

Figure 2. Variation of annual cost with voltage regulation for a complete lighting distribution system (feeders and branch circuits)

Voltage regulation based upon connected load. Energy losses based upon 70 per cent of connected load for 2,000 hours per year at two cents per kilowatt-hour. Capital cost includes: interest 3.5 per cent; depreciation 2 per cent; taxes and insurance 1.5 per cent



are, of course, subject to the variables mentioned in the preceding paragraph, but, for the values used, show the sum of carrying charges and energy losses to be at a minimum when the capacity of the conductor is about 20 per cent greater than the connected load requires. In fact, to increase the size to 40 per cent more than the minimum size would not increase the operating costs above that obtained with the minimum size.

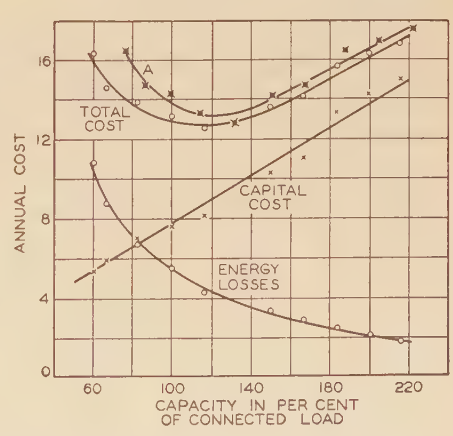
Adequacy

This is the point that should be emphasized, namely, that conductors may be installed for larger than the connected load, thus providing for unforeseen increases in load, without increasing the total cost of operation. As has happened so often with buildings wired for minimum first cost, if an increase in load is made five or ten years later, the provision of sufficient capacity in the distribution system becomes an expense that could have been avoided.

The case of an adequate original installation is illustrated by the lighting distribution system for a bank- and office-building in Philadelphia, Pa. The original intensity

Figure 3. Variation of annual cost of a feeder with capacity, based upon National Electrical Code ratings for connected load

Energy losses based upon 50 per cent of connected load for 2,000 hours per year at two cents per kilowatt-hour. Capital costs same as in figure 2



Curve *A* indicates the total cost if heat-resisting insulation and capacities as specified by the National Electrical Manufacturers Association are used

of illumination in 1928 was eight to ten foot-candles in the office spaces. Branch circuits were of number 12 wire with three to six outlets per circuit, and feeders were made considerably larger than required by the connected load. By 1939, the illumination intensities in 70 per cent of the offices had increased to from 15 to 20 foot-candles, and, although some changes have been made in branch-circuit wiring, the original conduit installation never has become inadequate and no change whatsoever has been necessary in the feeders. Part of the feeder runs, being concealed, cannot be changed without considerable cutting and consequent repairs to the building, yet they are large enough for even greater increases in load. The opposite case is illustrated by several instances of office lighting where the cost of the changes required in order to provide increased capacity for greater intensities of illumination was equal to, or more than, the cost of installing new fixtures.

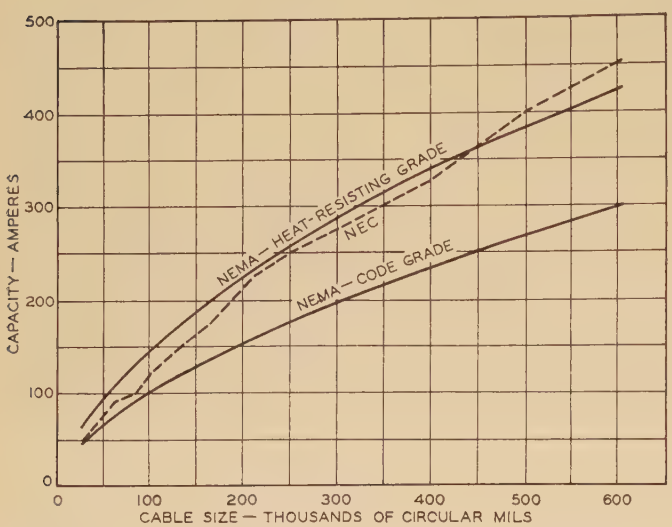


Figure 4. Current ratings for three wires in conduit, as specified by National Electrical Code and National Electrical Manufacturers Association

It is difficult and often impossible to estimate the load that may be added to an installation in any great period of time. It would appear, however, that for lighting loads additional capacity equal to 50 per cent of the connected load may be economically justified. This would be approximately equivalent to designing the system for two-per cent voltage regulation, in which case the 50-per cent increase in load if installed would increase the regulation to three per cent. For motor loads, the type of building or industry must be considered, with the additions that may be made in the future. An allowance of 25 to 50 per cent of the connected load should be found economical and is suggested as a minimum, where no additions are contemplated. Since the maximum load or demand for power purposes is usually well below the connected load, conductors 50 per cent larger than required by the connected load ordinarily will provide for a 100- to 200-per cent increase in demand.

Conductor Capacities

In connection with the provision of adequate capacity, consideration must be given to the report of the subcommittee on determination of maximum permissible current-carrying capacity of code-insulated wires and cables of the National Electrical Manufacturers Association. Figure 4 shows graphically the capacities of number 6 (American Wire Gauge) and larger rubber-insulated wires as given by the 1937 National Electrical Code and as determined by the NEMA investigations for three wires in conduit. In the sizes from number 14 to number 8 the NEC ratings are about equal to those given by NEMA for code-grade insulation, but for number 6 and larger the NEMA rating is lower and the difference becomes proportionately greater as the size is increased. For heat-resisting grade, however, the NEMA ratings are slightly better than NEC ratings, up to 400,000 circular mils.

In table II a comparison of the cost of conduit and wire installed for both code and heat-resisting grades is given with the capacity of each, based on the NEMA table for three-wire systems. This clearly indicates that heat-resisting rubber insulation is to be preferred to a larger size of code grade to obtain the required capacity.

Table II. Comparison of Costs of Conduit and Wire, Installed—Code Grade and Heat-Resisting Grade

Grade	Conductor Size	Amperes Capacity, NEMA	Approximate Cost per 100 Feet Installed, Three Wires in Conduit
Code	1/0	105	$101
Heat resisting	2	115	80
Code	4/0	160	146
Heat resisting	2/0	173	112
Code	400,000 cir mils	233	215
Heat resisting	4/0	230	153

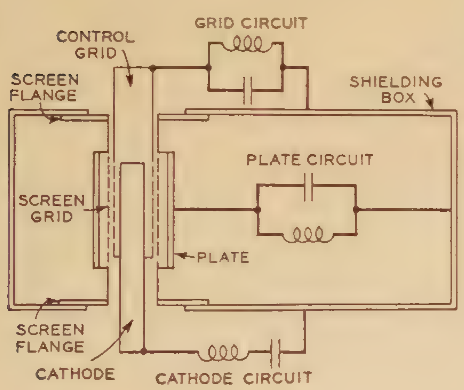
The NEMA ratings for heat-resisting grade differ only slightly from the NEC ratings in the larger sizes, and the difference in cost between code grade and heat-resisting grade is of the order of five per cent of the total cost of the conduit and wire installation; thus the use of heat-resisting insulation and NEMA ratings will not materially affect the curves of figures 2 and 3. This is illustrated in figure 3 by curve *A*.

With the many variables to be considered in the design of distribution systems within buildings, each installation must be considered as a separate problem and be designed to fit the needs as nearly as possible. It is evident that more consideration should be given to adequacy for the future, and it is hoped that the data presented herein will illustrate the point that even though no material increase in load results after a number of years, an installation having more than the capacity required by code rules is economical. With the use of the better grades of insulation, the electrical-system conductors should last as long as the building; but there is no economy in installing conductors that will give this service if in 5, 10, or even 15 years they are to be scrapped for larger conductors.

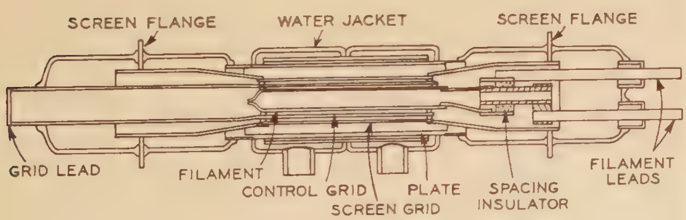
A 20-Kw Tetrode for Ultrahigh-Frequency Transmitters

THE advent of television emphasized the need for a power-amplifier tube capable of delivering kilowatts of power into wide-band circuits at carrier frequencies above 40 megacycles. To obtain such output with wide-band circuits, a low output capacitance and consequently a small anode area are required. The result is high current and high dissipation per unit area. For satisfactory operation at high frequencies, the electron transit time must be small, necessitating small interelectrode spacings. These requirements are interrelated and in some measure conflicting.

On the basis of an analysis of the foregoing considerations, and to meet specific requirements, a tube was designed to deliver 20 kw peak power at 120 megacycles into a circuit of 2 megacycles band width. The design and construction of this tube and test results obtained were discussed in a three-part paper entitled "Development of a 20-Kw Tetrode for Ultrahigh-Frequency Transmitters," by A. V. Haeff (A'31), L. S. Nergaard, W. G. Wagener, P. D. Zottu, R. B. Ayer, and H. E. Gihring, presented at the annual convention of the Institute of Radio Engineers, New York, N. Y., September 20–23, 1939.



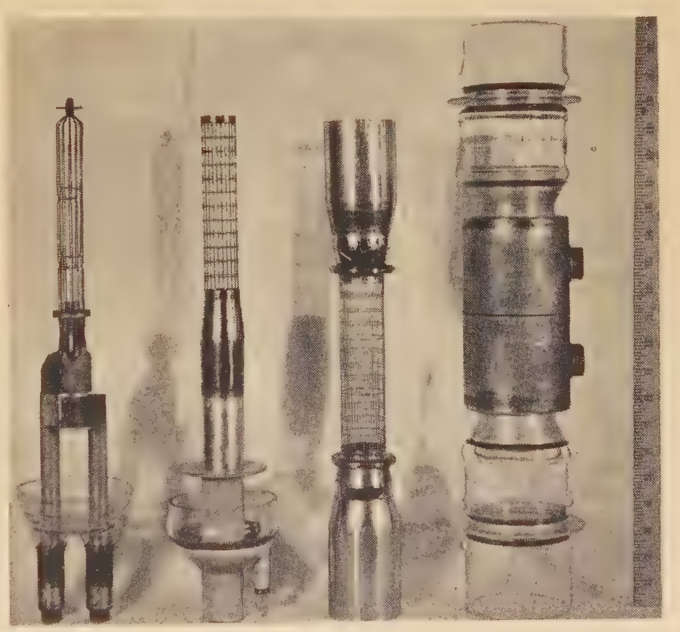
Schematic diagram of the tube and its associated circuit. A cross section of completed tube is shown below



To avoid neutralization difficulties, the cylindrical tetrode design was adopted. Once this design had been decided upon, it was necessary to consider the tube in relation to its circuit in order that the full advantages of the screen grid might be realized. This was particularly necessary because the carrier frequency is high enough so that the tube and its circuit tend to merge into a composite unity rather than remain distinct elements. After this problem had been examined in detail and model tests had been made, the arrangement shown schematically in the accompanying diagram was adopted. The screen-grid is mounted on radial flanges. These flanges are connected to the shield which encloses the output circuit. As may be noted, the cathode and control grid are brought out at opposite ends of the tube, which permits independent tuning of the grid and cathode circuits and makes the tube well suited to operation in a push-pull circuit.

The mechanical design and construction of the tube to meet the electrical requirements involved problems not usually encountered in power tubes. The high power and high frequency made the elimination of insulating members in the active region imperative. Consequently, the electrodes were supported by the glass work at each end of the tube. The severe thermal conditions required water-cooling of the anode, the control-grid support, and the filament leads.

Tests show that the tube is capable of being operated stably at all frequencies up to 80 megacycles or higher and delivering power outputs as high as 25 to 28 kw per tube at an efficiency of about 55 per cent. It has a peak plate current of at least 25 amperes which is sufficient to furnish 20 kw per tube when operating as a television radio-frequency amplifier with a calculated band width of 9 megacycles.



Component parts of the tube, left to right: filament structure, control grid, screen grid, and anode assembly with integral water jacket. Below is shown the completed tube; it is $30^1/_2$ inches long and $5^1/_2$ inches in diameter

A Brief Summary of Bridge Networks

WALTER J. SEELEY
MEMBER AIEE

An outline classification of bridge networks that may be of assistance to users of bridges, students, and others interested in the subject

THE BRIDGE CIRCUIT, which was first introduced in 1833 by S. H. Christie, is one of the most useful electric circuits ever devised. It is so versatile that one could obtain a very liberal training in electric circuits if study were confined to it alone. Sir Charles Wheatstone, in 1843, made the first real application of the network when he applied it to the comparison of resistances. From that time his name has been attached to the use of the bridge for d-c determinations of resistance. Heaviside tried to call it the Christie, but the name did not seem to stick. Maxwell, in 1865, was the first to attempt the determination of inductance in a bridge circuit, using a ballistic method; later, in 1873, he described several forms of balances or bridges. His bridges form the basis of many modern impedance bridges.

The modern a-c bridge is due to the developments of Max Wien, who first applied alternating current to Maxwell's bridges in 1891. He also proposed networks of his own invention for measurement purposes. From then on new networks have been devised and new applications have been made until today the amount of literature on the subject is so utterly amazing as completely to bewilder the engineer seeking information on the subject. Aside from measuring the values of the fundamental constants, resistance, inductance, and capacitance, with their related constants, conductance, susceptance, admittance, and impedance, the bridge network has been applied to the determination of frequency, speed, time, power, power factor, electromagnetic forces, the soundness of welds, and acoustic impedance. It is also used to measure deflection of beams, torsion of large shafts, shaft horsepower, pressures in engine cylinders, magnetic fields, stresses in setting concrete, small motions, vacua, and many other things.

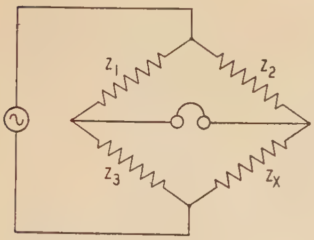


Figure 1. Four-arm impedance bridge

The purpose of this article is to present a brief classification of bridge networks (mutual-inductance bridges not included) according to name, giving balance equations for each. Theory, operation, and application of the various types are referred to in a selected bibliography. The development and classification for the most part is a brief review of the one first proposed by J. G. Ferguson.[1] Others have been proposed, but for the purpose of this article Ferguson's classification seems to be the one most logical to follow.

General Theory

At balance, the products of opposite arms of a four-arm bridge are equal, all impedances being expressed in complex notation for final evaluation of the unknown. The balance conditions are then obtained by equating reals and imaginaries. Thus, at balance from figure 1,

$$Z_1Z_x = Z_2Z_3 \tag{1}$$

from which

$$R_x + jX_x = \frac{(R_2+jX_2)(R_3+jX_3)}{R_1+jX_1} \tag{2}$$

In terms of magnitudes,

$$|Z_1||Z_x| = |Z_2||Z_3|$$

and

$$\theta_1+\theta_x = \theta_2+\theta_3 \tag{3}$$

where the θ's are the power-factor angles of their respective impedances. By means of equation 3 the power factor of the unknown impedance may be determined.

The bridge network usually consists of two fixed arms, a third variable balancing arm, and a fourth arm containing the unknown. In actual operation, the process of balancing requires two adjustments, one for magnitude and one for phase, corresponding respectively to the real (R) and imaginary (X) components of the unknown impedance. In general, for ease in manipulation the real component (R) of the impedance in the third, or variable, arm should balance the real component (R) of the unknown; and

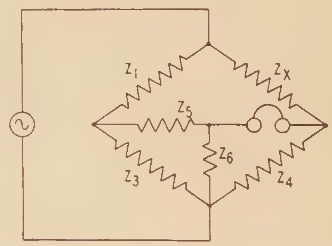


Figure 2. Anderson bridge

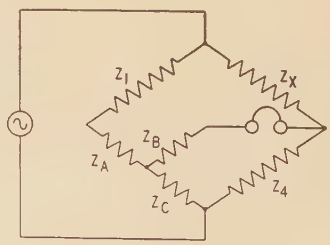


Figure 3. Anderson bridge with impedances Z_3, Z_5, and Z_6 (figure 2) transformed into equivalent star network

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1. For numbered references see bibliography at end of article.

the imaginary component (X) of the impedance of the third arm should balance the imaginary component (X) of the unknown.

If, in figure 1, the arms Z_1 and Z_2 are the fixed arms and Z_3 the variable balancing arm, the bridge is known as a ratio-arm bridge, with Z_1 and Z_2 the ratio arms; if Z_2 and Z_3 are the fixed arms and Z_1 the variable balancing arm, the bridge is known as a product-arm bridge, with Z_2 and Z_3 the product arms. For the ratio-arm bridge,

$$Z_x=\frac{Z_2}{Z_1}\cdot Z_3 \tag{4}$$

and for the product-arm bridge,

$$Z_x=Z_2Z_3\cdot\frac{1}{Z_1} \tag{5}$$

This classification of bridges into ratio-arm and product-arm types may seem to be somewhat artificial, as it is sometimes difficult to decide into just which type a particular bridge should be classified. It is a fairly simple classification, however, has been extensively analyzed,[1] and is subject to but few exceptions.

In the ratio-arm bridge the unknown is balanced by a series impedance, Z_3, in an adjacent arm, and the vector ratio Z_2/Z_1 must be real or imaginary (but not complex) with the difference between their phase angles $(\theta_2-\theta_1)$ equal to 0, 180, or ± 90 degrees. Solving equation 4 for the case where Z_2/Z_1 is real $(\theta_2-\theta_1=0$ or 180 degrees),

$$R_x+jX_x=\frac{Z_2}{Z_1}(R_3+jX_3) \tag{6}$$

from which, upon equating reals and imaginaries,

$$R_x=\frac{Z_2}{Z_1}R_3=\frac{R_2}{R_1}R_3=\frac{X_2}{X_1}R_3 \tag{7}$$

and

$$X_x=\frac{Z_2}{Z_1}X_3=\frac{R_2}{R_1}X_3=\frac{X_2}{X_1}X_3 \tag{8}$$

When Z_2/Z_1 is imaginary $(\theta_2-\theta_1=\pm 90$ degrees), equation 6 yields

$$R_x=\frac{Z_2}{Z_1}R_3=-\frac{X_2}{R_1}X_3=\frac{R_2}{X_1}X_3 \tag{9}$$

and

$$X_x=\frac{Z_2}{Z_1}X_3=\frac{X_2}{R_1}R_3=-\frac{R_2}{X_1}R_3 \tag{10}$$

In the product-arm bridge the unknown is balanced by a series or parallel impedance, Z_1 (usually a capacitance and resistance in parallel) in an opposite arm, and the vector product Z_2Z_3 must be real or imaginary (but not complex) with the sum of the phase angles $(\theta_2+\theta_3)$ equal to 0, 180, or ± 90 degrees. When Z_2Z_3 is real $(\theta_2+\theta_3=0$ or $180°$), equation 5 gives

$$R_x+jX_x=Z_2Z_3\cdot\frac{1}{Z_1}=Z_2Z_3Y_1=Z_2Z_3(G_1-jB_1) \tag{11}$$

from which, upon equating reals and imaginaries,

$$R_x=Z_2Z_3G_1=R_2R_3G_1=-X_2X_3G_1 \tag{12}$$

and

$$X_x=Z_2Z_3(-B_1)=-R_2R_3B_1=X_2X_3B_1 \tag{13}$$

When Z_2Z_3 is imaginary $(\theta_2+\theta_3=\pm 90$ degrees), equation 11 yields

$$R_x=X_2R_3B_1=X_3R_2B_1 \tag{14}$$

and

$$X_x=X_2R_3G_1=X_3R_2G_1 \tag{15}$$

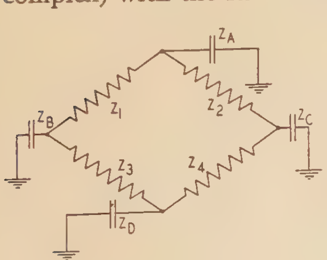


Figure 4. Unshielded impedance bridge showing shunt capacitances to ground

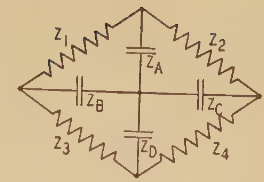


Figure 5. Shielded impedance bridge; stray impedances interconnected with main bridge arms

Two exceptions to the foregoing rules for ratio-arm and product-arm bridges should be noted. In one use of the Wien bridge[33] a small capacitor, C_2 (not shown in figure 10) is used in parallel with R_2, making Z_2/Z_1 complex with $\theta_2-\theta_1$ not equal to 0, 180, or ± 90 degrees. In the generalized Schering bridge[45] with a capacitor, C_3 (not shown in figure 15) in parallel with R_3, the product Z_2Z_3 is complex with $\theta_2+\theta_3$ not equal to 0, 180, or ± 90 degrees. In both these particular cases the bridge relations are determinable, and the bridges can be balanced. See the references for details.

Bridges of the Anderson type (figure 2) may be solved for balance by transforming the $Z_3Z_5Z_6$ mesh to its equivalent star network by means of the transformation equations:

$$Z_A=\frac{Z_3Z_5}{Z_3+Z_5+Z_6},\quad Z_B=\frac{Z_5Z_6}{Z_3+Z_5+Z_6},\quad Z_C=\frac{Z_3Z_6}{Z_3+Z_5+Z_6} \tag{16}$$

This results in a four-arm bridge (figure 3) for which the equation of balance is

$$Z_xZ_C=Z_4(Z_1+Z_A) \tag{17}$$

and

$$Z_x=\frac{Z_4}{Z_3Z_6}[Z_1(Z_3+Z_5+Z_6)+Z_3Z_5] \tag{18}$$

The Wagner Ground

When high frequencies or high potentials are used precise bridge balances are difficult to obtain on account of stray impedances and the impedances to ground of the various bridge arms. These impedances are usually capacitive in nature and variable in value depending upon the relation between the arms and surrounding objects. Although the capacitances may be small, the current through them may be large since $I=V\omega C$, where I is the

current, V is the applied voltage, ω is 2π times the frequency, and C is the capacitance. The bridge of figure 4 (supply and detector circuits omitted for simplicity) shows that the impedances to ground, Z_A, Z_B, Z_C, Z_D, shunt the bridge arms thus making precise balances impossible. Various schemes are used to eliminate the effects of these impedances to ground, namely, double shielding, the Wagner ground, and combinations of shielding and the Wagner ground.

The chief purpose of shielding is to make the ground impedances definite in magnitude, location, and effects. It is possible by very elaborate and well-designed double shielding[11,13] to localize and concentrate the capacitance effects between the diagonal corners of the bridge. This places the capacitance in one case in parallel with the detector and in the other in parallel with the source of supply, thus preventing them from affecting the bridge balance. An adjustment is sometimes provided to take care of any remaining unbalance to ground of the detector circuit. The shielding also may be designed[39] to localize the stray capacitance across one particular arm of the bridge where it is taken care of by proper adjustments in the initial calibration. Figure 5 is the same as figure 4, but redrawn to show the interconnection of the stray impedances with the main bridge arms. The impedances Z_1, Z_2, Z_3, Z_4 constitute the ordinary bridge arms, and Z_A, Z_B, Z_C, Z_D, represent the impedances of the four corners to ground or to a shield. It has been shown[7,11,47] that the ordinary bridge relation, $Z_1Z_4=Z_2Z_3$, holds if

$$Z_A/Z_D=Z_2/Z_4=Z_1/Z_3 \tag{19}$$

or

$$Z_B/Z_C=Z_3/Z_4=Z_1/Z_2 \tag{20}$$

These equations mean that, by properly balancing the shields during manufacture and providing a shield adjustment, the bridge balance may be made independent of any stray or extraneous coupling impedances.

Another scheme used to nullify the effects of stray and distributed capacitances is to make use of partial shielding and the Wagner ground. The bridge construction is simpler, but additional operations are required in the balancing process. Figure 6 shows a bridge (detector circuit omitted) with two additional adjustable impedances, Z_5, Z_6, connected in series across the supply circuit. These last two grounded impedances constitute the Wagner ground. Partial shielding is used to make the stray impedances to ground fixed and definite in value. The impedance Z_B is now in parallel with Z_5, and Z_C is in parallel with Z_6, thus removing them both from the bridge circuit proper. The remaining impedances, Z_A, Z_D, are removed by the use of the added Wagner ground. Since Z_B and Z_C now have been incorporated with Z_5 and Z_6,

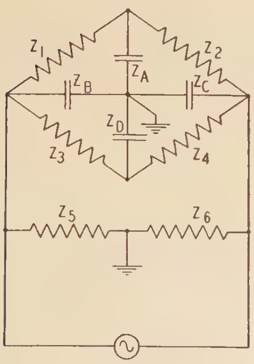


Figure 6. Shielded impedance bridge with Wagner ground

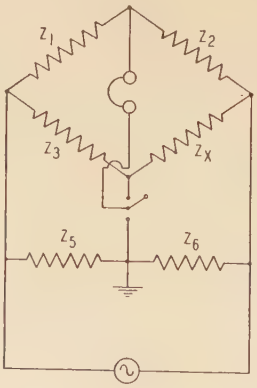


Figure 7. Diagram illustrating the process of balancing with the Wagner ground

Figure 8. Impedance bridge (Maxwell)

$R_1=R_2$; R_3, L_3 variable.
Measures L, R in terms of L, R.
At balance:
$R_x=R_3$ $\qquad L_x=L_3$

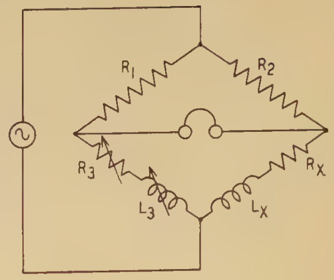


Figure 9. Impedance bridge

$R_1=R_2$; R_3, C_3 variable.
Measures C, R in terms of C, R.
At balance:
$R_x=R_3$ $\qquad C_x=C_3$

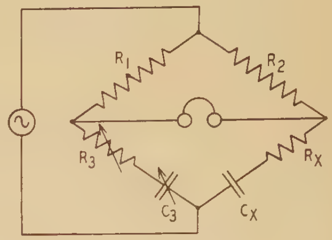


Figure 10. Wien bridge

$R_1=R_2$; R_3, C_3 variable.
Measures C and parallel R in terms of C, R, and f.
At balance:

$$C_x=\frac{R_1}{R_2}\cdot\frac{C_3}{1+\omega^2C_3^2R_3^2}$$

$$R_x=\frac{R_2}{R_1}\cdot\frac{1+\omega^2C_3^2R_3^2}{\omega^2C_3^2R_3}$$

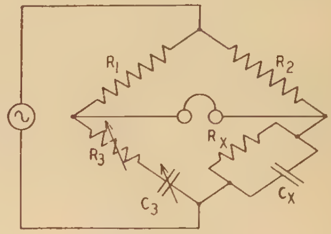


Figure 11. Owen bridge

Difference between phase angles of ratio arms is ±90 degrees.
Measures L in terms of C and R.
At balance:

$$R_x=R_2\frac{C_1}{C_3}-R_4; \qquad L_x=R_2R_3C_1$$

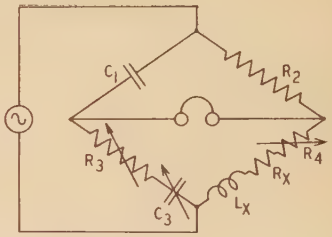
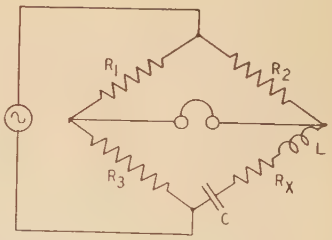


Figure 12. Resonance bridge

Measures L in terms of C and f; C in terms of L and f; or f in terms of L and C.
$R_1=R_2$
At balance:

$$R_x=R_3 \qquad L=\frac{1}{\omega^2C}$$



Product-Arm Bridges

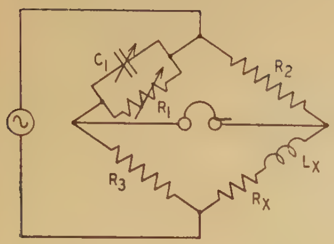


Figure 13. Maxwell bridge

Measures L in terms of R and C.
At balance:

$$R_x = R_2 R_3 \cdot \frac{1}{R_1} \qquad L_x = R_2 R_3 C_1$$

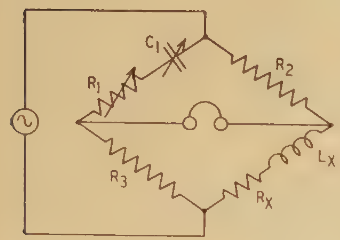


Figure 14. Hay bridge

Measures L in terms of R, C, and f.
At balance:

$$L_x = \frac{R_2 R_3 C_1}{1 + R_1^2 \omega^2 C_1^2}$$

$$R_x = \frac{R_1 R_2 R_3 \omega^2 C_1^2}{1 + R_1^2 \omega^2 C_1^2}$$

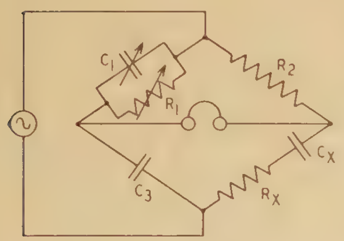


Figure 15. Schering bridge

Measures C and R in terms of C and R.
Sum of phase angles of product arms equals ±90 degrees.
At balance:

$$R_x = \frac{R_2}{C_3} \cdot C_1 \qquad C_x = \frac{C_3}{R_2} \cdot R_1$$

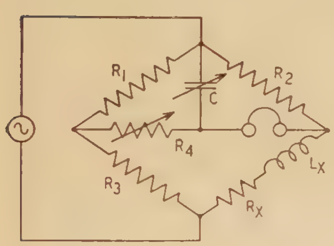


Figure 16. Anderson bridge

Measures L in terms of R and C.
At balance:

$$L_x = C R_2 \left[R_4 \left(\frac{R_3}{R_1} + 1 \right) + R_3 \right]$$

$$R_x = \frac{R_2 R_3}{R_1}$$

the circuit of figure 6 reduces to that of figure 5, for which equation 20 applies. That is, the ordinary bridge relation, $Z_1/Z_2 = Z_3/Z_4$, holds when

$$Z_5/Z_6 = Z_3/Z_4 = Z_1/Z_2 \tag{21}$$

where Z_5 now includes Z_B, and Z_6 includes Z_C. All that is necessary, therefore, is to balance Z_5 and Z_6 against Z_1 and Z_2 (or Z_3 and Z_4) and all stray impedances (usually capacitances) are removed from the bridge circuit. This is a very convenient and much used circuit. The process of balancing is simple. The bridge is first balanced as nearly as possible with the switch closed in the upper position (see figure 7); then with the switch in the lower position it is rebalanced. The process is repeated until exact balance is obtained; then the relations of equation 21 have been satisfied and the balance equation may be applied to determine the unknown. The arms Z_5 and Z_6 must be of such a nature that they form a balanceable bridge with Z_1 and Z_2. By virtue of its ability to remove undesired capacitances from the influence of the balance relations, the Wagner ground is also frequently used for measurements on three-terminal capacitors, cables, and for other measurements where direct capacitance rather than total capacitance is required.[29] Its chief use, however, is in the measurement of small capacitances and power factors.

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Index

CAPACITANCE
- Average: 8, 20, 48.
- Small: 3, 8, 18, 32, 33, 35, 45, 55.
- Large: 21.
- Direct: 8, 29, 55, 57, 58.

FREQUENCY: 36, 44.

FREQUENCY, AUDIO: 3, 16, 17, 18, 19, 21, 30, 31, 33, 39, 46, 48.

FREQUENCY, RADIO: 15, 16, 17, 22, 23, 24, 25, 30, 31, 33, 70.

INDUCTANCE
- Average: 8, 16, 20, 37, 38, 39, 40, 56.
- Small: 20, 28, 42.
- Large: 21, 39.
- Inductance with superposed direct current: 41, 43.

INSULATION: 3, 30, 33, 35, 45, 49.

POWER FACTOR: 3, 8, 18, 26, 27, 33, 35, 45, 46, 47, 49, 50, 51, 53, 54.

UNIVERSAL: 17, 19, 20, 23.

VACUUM TUBE: 8, 55, 58.

VOLTAGE, HIGH: 8, 34, 35, 46, 49, 50, 51, 52, 53, 54.

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Wagner Ground (see also: 3, 8, 18)

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Journal, volume 6, 1927, pages 142–71; AIEE TRANSACTIONS, volume 45, 1926, pages 1266–77. A comparison bridge good up to 50 kilocycles. Good discussion of shielding.

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Some Unsolved Problems in Transportation

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A review of some of the unsolved problems facing electrical engineers of the railroad and urban-transportation industries points to the need for a research organization supported by the operating companies, to stimulate technical developments in this field.

THE ABILITY to determine and state what comprises the outstanding problems in any field of activity implies very extensive knowledge of the developments in that field and to state the unsolved problems implies even more than this. When we begin to consider what ought to be done or attempted, the assumption is that there is an accepted standard or goal toward which we are striving. The author knows of no clear and comprehensive statement of the goals or ends of modern transportation. However, competition is making increasingly clear that if public transportation is to survive, the industry must strive toward higher levels of convenience, speed, comfort, efficiency, and attractiveness. Today, the public assumes that safety has been given adequate consideration. This, then, is taken as our major premise—that any development that offers hope for improving these factors, through the effort of electrical engineers, is a proper problem for consideration.

Obviously, an article such as this can only scratch the surface of the potential electrical problems in the transportation field, for, after all, this subject is one that would be more appropriate for a large research or scientific organization. Lacking such an organization, the author has attempted to state some of the problems facing electrical engineers of the transportation industry, particularly those in the railroad and urban transportation field.

Power Distribution to Electric Railways

With the development of superpower networks and relay systems furnishing power of utmost reliability, it is taken for granted today that the great power systems supplying our industrial and domestic power needs will likewise furnish power for the electrification of transit systems. Problems involved in the generation and transmission of this power are beyond the scope of this article. However, vital unsolved problems are involved in the purchase and supply of this power.

The power contract itself, which involves the determination of an equitable method for allocating demand charges is one such problem. A problem of more vital concern is the use of commercial voltages and frequencies for heavy railroad electrifications. The economic advantage of using central-station power for railroad electrification is due chiefly to two factors:

1. The energy component of the power rate is lower because the central station can operate larger and consequently more efficient generating units.

2. The demand component of the power rate is lower due to the diversification of railway, commercial, and domestic loads with resulting high load factor, and because extensive joint use of generating and transmission facilities is possible.

It is obvious that the maximum economic advantage of using central station power is obtainable only if the catenary is operated at commercial voltage and frequency. Ten years' experience with an urban-railway power-distribution system wherein all power is furnished to railway substations over regular commercial high-voltage lines,

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has convinced the author that joint use of transmission lines and distribution facilities is dependable and economical, and that with suitable railway and power-system design, such commercial feeders in no respect jeopardize the transportation service.

A review of the existing power distribution facilities of various heavy transportation systems raises the question whether the transportation power-system design has been adequately or fully co-ordinated with the power-supply systems.

Although engineers in the United States seem to be satisfied with a variety of direct-current and 25-cycle distribution systems, several European countries are vigorously experimenting with the use of commercial voltages and frequencies. From the results obtained, it would seem that there are distinct possibilities for the adoption and use of commercial types of power supply for heavy railroad electrifications which should result in reduction of the large investment required for main-line electrification. The solution of the problem involved in making such equipment commercially available offers a challenge to the skill and ingenuity of electrical engineers.

Closely related to this problem of power supply is the problem of constructing a catenary and distribution system at a lower cost than that of systems now available. One of the great difficulties in the electrification of main-line railroads is that the catenary and distribution system must be installed complete over fairly large areas in order to secure economies in operation and it must be installed on the basis of handling the maximum traffic expected within the near future. This requires a heavy investment involving large fixed charges that continue even if the traffic does not come up to expectations. The present trend of main-line motive power to self-contained units is largely due to an effort to avoid these fixed charges. Should a solution be found that would permit a drastic reduction in the cost of catenary and distribution systems, this trend might easily be reversed.

Considering further the various distribution systems of the electrified rail lines of the United States, it is clear that another major unsolved problem in electrical engineering is involved in the standardization of these systems.

When we consider problems of this kind from the standpoint of national defense, they take on an even greater significance. Transportation units must be capable of mobilization in various parts of the country. England, France, and Germany realizing this have adopted national standards.

Standardization of motive power units is not necessary to obtain the essential requirements for mobility, but standardization is desirable in this respect if the railroads are to secure the tremendous economic advantage of mass production.

For the welfare of the electric transportation system as a whole and everyone individually involved in it, standardization is imperative. Major competition today is with transportation units produced by mass-production technic. This is true not only of private cars, but also of motor- and air-transportation units. We need not fear that standardization will impair initiative and new development, because the driving force of competition is present today in the transportation field in greater degree than ever before.

Perhaps if some degree of standardization can be attained, the suggestion contained in the National Power Survey—The Use of Electric Power in Transportation, issued in 1936 by the Federal Power Commission, for an increased electrification mileage of 12,000 miles of track on 20 steam railroads, involving an annual energy consumption of 5,000,000,000 kilowatt-hours, can be made a reality or even substantially increased.

Power Utilization by Transportation Units

The elimination or the substantial reduction of the losses involved in starting d-c traction motors is a problem that has long concerned transportation engineers. Early in the history of the industry, these losses were reduced by approximately one-half with the adoption of series parallel control, which has the further advantage of providing an efficient half-speed running point.

The past few years have seen rapid developments in the control equipment of urban-transportation units. Competition with rubber-tired vehicles makes imperative the use of accelerating rates that closely approach the limits determined by rail adhesion. In order to maintain smooth acceleration from the starting point until the full motor voltage is reached, it has been found desirable to eliminate transition points. The reduction in first cost and maintenance occasioned by the simplified control of a single motor, is further reason for modern trolley coaches and street cars to use rheostatic control.

The ideal system of control for transportation equipment would provide for the total elimination of control-resistor losses and make available an infinite number of efficient low-speed running points. The need for efficient d-c control seems to be appreciated to a greater extent in Europe than in America. This is evident from the fact that development along these lines has progressed farther, and that the foreign technical press carries more articles relating to this problem than the American technical press.

The Metadyne control, recently furnished on 73 new multiple-unit equipments for the London Passenger Transport Board, is one answer to this problem, although the equipment involved at the present state of development is rather complicated and heavy for general application to small urban-transportation units.

The name "Metadyne" has been given to a type of d-c machine in which special use is made of armature reaction to control machine characteristics. Metadynes have been built to act as rotary transformers of d-c power and applied to control railway equipments. This control is arranged to convert power from constant voltage to variable voltage so as to give any desired speed-torque characteristics to the traction motors from standstill to full speed and from full speed to stop. For example, for the comfort of passengers when using a high rate of acceleration, it is desirable to start with low acceleration, to

increase the acceleration rapidly at a steady rate until a maximum is reached, and then to decrease the acceleration steadily so that when the power is cut off the passengers will not be inconvenienced. Similarly when braking regeneratively, it is desirable to start with a low rate of retardation, increase it to a maximum, and finally to ease off the rate, so that just before stopping the rate of retardation is low. These features can be obtained with the Metadyne in a very smooth manner by varying the natural characteristics.

Experiments have been made with inverters and d-c transformers of the commutator type, in which only light rotating parts are used and the actual transformation of power is accomplished by highly efficient static transformers. Such a device would seem to offer possibilities for producing smaller and lighter units than the metadyne does at present.

There seems to be no fundamental reason why an efficient d-c control cannot be evolved. Perhaps the problem needs only to be emphatically brought to the attention of research organizations. Certainly it should be listed as one of the unsolved problems of electrical engineering in the transportation field in the United States.

Another problem is the definite need for some simple efficient equipment that will convert 600-volt direct current to low-voltage alternating current. On 600-volt multiple-unit cars, especially those operated from third rail, the only method now commercially available for converting from third-rail voltage to low-voltage direct or alternating current is by means of a motor generator set with a 600-volt d-c motor and a low-voltage generator. The ideal solution of this and allied problems would be a device of the nature of a vibrating inverter that would convert from 600-volt direct current to low-voltage alternating current which could be used directly for lighting, or rectified for battery charging, or both. Such a device should have very light-weight moving parts so that there would be no appreciable kinetic energy to dissipate at times of sudden voltage reversals due to third-rail gaps. Means should be incorporated in the device for maintaining constant a-c output voltage with varying d-c input voltage. Inverter tubes would be excellent for this purpose if they could be developed to withstand the high inverse voltages involved and to deliver the necessary power outputs. The problem of rectifying alternating current from such a source to low-voltage direct current, of course, can be solved in a number of well-known ways.

Still another problem is the need, on certain classes of cars and by certain fixed equipment at remote locations, for a small amount of power for lighting and signal lights without using the conventional systems of generation. The conventional systems of power supply such as straight storage batteries, storage batteries and axle generators, or self-contained gasoline engines all seem to be too expensive in first cost and too high in maintenance for the small amount of power required.

A possible solution is the use of primary batteries with some type of fluorescent lamp requiring very little power, yet giving considerable light. Together with these would be required an efficient inverter for the transformation of power to secure alternating current for the operation of the fluorescent lights. The inverter presents a problem because of the high efficiency required with a low power input.

Other problems of power utilization on vehicles would be immensely simplified if storage batteries of greatly improved characteristics for transportation purposes could be developed. While great improvements in storage batteries, both of the lead-acid and alkaline types, have been made in the last 20 years, they have been refinements rather than fundamental changes. What is needed is a battery of radically new characteristics.

Suitable thermostatic control of heat on transportation units is still an unsolved problem. The use of a single thermostat on a multiple-unit car is far from satisfactory, particularly on runs where doors are opened frequently because of stops being close together on one portion of the run, and closed continuously on other portions where there are no stops. A solution of this problem is desired without resorting to the use of forced ventilation.

There is also a great need for a better d-c lightning arrester. At present, the most effective arrester for d-c traction vehicles is the aluminum-cell arrester. No case is known of damage to equipment where the vehicle has been equipped with one of these devices and it was in working order.

However, these arresters are expensive to maintain, require careful maintenance, and in many parts of the country where they have to be kept operating 12 months of the year they must be protected against freezing in winter and overheating in summer, the film being very critical at high temperatures. On 3,000-volt d-c cars and locomotives, 12 of these jars have to be used in series and high short-circuit currents can be caused by jar failures.

For a-c circuits, the Thyrite resistance arrester has been developed and has superseded the aluminum cell. For various reasons, this material cannot yet be used on direct current, but it would seem that a similar material could be developed for use on d-c circuits.

Possible Electrical Solutions of Operating Problems

There is no doubt that electrical engineering can play a considerable part in solving some of the more difficult operating problems of transportation. Consider, for instance, the problem of communication between the vehicle and the dispatcher. With the present state of development of ultrashort-wave radio such communication is entirely feasible, yet out of reach economically. It is obvious that such a development would greatly expedite the handling of emergency traffic problems. Another communication problem, which, however, seems about solved is that of communication between the ends of long freight trains.

The electric fare box is a splendid development. But if an electrical device could be developed that would record and collect the amount of the individual fare in proportion to the length of the individual ride, a veritable

revolution in urban transportation might result. At present, the major part of short-haul rides is lost because the cost of these rides is, as a rule, out of all proportion to the value to the individual patron.

Notwithstanding the use of many clever mechanical devices, the formation of sleet on trolley wire, and on third rails of the over-running type, is in many parts of the country a serious operating problem. Various schemes have been proposed for preventing sleet from forming or, at least, to keep it from sticking tightly to the wire or rail. However, no satisfactory solution has yet been found.

It might be possible to develop some sort of material that would serve as a coating and would prevent sleet from forming. The problem of preventing the current collectors from removing such material, of course, would present considerable difficulty.

On many transportation lines, particularly on subways, the problem of announcing the approaching station is receiving considerable attention. To date, no infallible scheme has been developed that is economically feasible.

The same problem is also present to a certain extent on main line trains, and it is only reasonable to suppose that the train of the future will include some provision to supersede the brakeman's "grunt" which has become synonymous for practically any station on the line.

In connection with signaling and train control, there seems to be a problem of the conduction and detection of very small currents at low voltage through wheels of the free-wheeling type. In general, however, modern systems of train control and cab signaling have been perfected to such an extent that the major problem would seem to be that of financing their installation. Automatic train control is, of course, a unique advantage from the safety standpoint that rail transportation has over all of its competitors. Unsolved problems in this field certainly merit serious consideration.

Another safety problem that should receive attention is that of providing timely and adequate warning in the event of fractured or broken axles.

The problem of recording headways between rail units or trolley coaches at a central dispatcher's office on urban transportation systems has been solved. Such a system, complete with automatic alarms, operating when pre-established headways are exceeded can be installed today at a reasonable cost. The satisfactory recording of motor coach headways, however, still remains an unsolved problem. Such a recorder, functioning without street treadles or attention from the coach operator, is urgently needed.

In general, it seems to the author that the advantages of centralized control and supervision of operation cannot be over emphasized. Such systems can be developed economically and extended over every phase of the power supply and distribution system with great advantage to the transportation service.

Improved Research Instruments

Despite the phenonenal development of scientific instruments, the use made of them by public-transportation agencies is not significant. Something is lacking here. No one questions that the essential factors making for convenience and comfort and therefore for public acceptance of transportation units are speed, smoothness of acceleration and retardation, absence of noise and vibration, illumination, and ventilation, yet the transportation unit is not periodically checked by suitable instruments with respect to these factors.

The performance of new equipment is not even specified and checked with regard to all of these factors. We still rely on our intuition and feelings after a demonstration ride to determine the most comfortable equipment. All of the factors mentioned are physical and therefore susceptible to quantitative measurement. There is no reason why recording instruments presenting a graphic picture of these factors as the transportation unit proceeds along its route should not be developed and used. The significance of these factors will be appreciated only after they have been recorded in some such manner.

One of the important physical factors that we have not yet succeeded in measuring is the presence of objectionable odors or fumes. If someone should develop an objective method of determining and graphically measuring these, we would undoubtedly solve the problem of their elimination.

Notwithstanding the need it is unlikely that instrument or meter manufacturers of their own initiative will develop extraordinary tools for furthering research and development work on transit systems for the reason that the market for such equipment would be so limited that the development would be unprofitable.

The multiplicity of problems facing the industry leads naturally to the vital unsolved problem of stimulating technical developments in the transportation field. Experience has demonstrated the relative ineffectiveness of individual operating companies in the fields of research and progressive achievement. Railway association committees are likewise relatively ineffective. They do excellent work, but the tempo of their achievement due to the very nature of the volunteer type of organization is inadequate to meet present-day competition. Individual manufacturing companies have made noble efforts to keep the public transportation industry abreast of the times. The money they can afford to spend on new development, however, is strictly limited to potential profits they can make from the sale of new equipment. When the prospects for the sale of new equipment vanish, the development program slackens at the very time when it should be accelerated. Somehow, the problem of maintaining an adequate research and development program must be solved.

Illustrative of what might be accomplished by an adequate approach is the result of several years' activity of the Presidents Conference Committee, the new PCC car—a revolution in urban transportation.

The development of equipment and improved standards for railways, as in practically all of the older industries, has been a sort of evolutionary process, that is, improvements have come through the elimination of the cause of faults and complaints. With the limited funds

available for research and development, no other technic was possible. Even with the maximum effort and co-operation only moderate progress is possible by using such a technic. The activity of various technical committees, through interchange of experience and ideas, stimulates and accelerates the evolutionary method, but the results are naturally the refinements of existing equipment instead of the development of revolutionary new methods and equipment.

If the necessary funds, time, and organization were available it would be possible to attack this problem in an entirely different way. The broad general objective could be established "a priori" or by means of a consumer or patron survey of results that should be accomplished. Research men and scientists could then set about obtaining all factual data relevant to the accomplishment of these results. After the physical factors entering into the solution had been isolated, performance specifications could be set up. Up to this time, no consideration need necessarily be given to past experience or to equipment available at present. The newly evolved specifications would provide the necessary standards by which to judge not only the performance of existing equipment, but also of all proposed equipment.

It is vital to observe that there is nothing final or absolutely conclusive about performance specifications developed in this way. The whole technic and development is based upon a premise that is constantly shifting with public sentiment. If noise were disregarded by the public yesterday but its elimination considered vital today, our performance specifications must be changed accordingly.

An organization designed to cope with problems in such a manner must be permanent and its activity continuous. If its financing were a charge against operating expense development would be greatly stimulated, and furthermore the acceptance and actual use of new developments would be expedited for the following reasons:

1. Operating companies are in direct competition with other forms of transportation and therefore have a keen interest in improving their competitive position. They are able to sense more quickly and accurately public demands in transportation than the more remote manufacturers of equipment. They would therefore initiate more quickly development work actually needed to meet public demands.

2. In an effort to realize on their contributions to the joint development fund, operating companies would do everything possible to put new developments into actual service.

3. Because new developments would not be loaded with manufacturers development costs, the initial cost of new equipment would be greatly reduced with consequent savings in fixed charges.

Such an organization supported by the operating companies and functioning with adequate resources would inevitably present to the manufacturers unsolved and worth-while problems of the industry that we cannot even comprehend today.

Power Plants Afloat

NO APOLOGIES need be offered for modern marine machinery. The industry is keeping well abreast of power developments. The average shore engineer would be favorably impressed with the power plant aboard any modern ship. Of course, in viewing a ship's installation one must keep in mind the limited space and the inevitable conflict that must occur in reconciling the different demands upon that space and the weight allowance for machinery in any given model. Certainly the fundamental axiom of ship construction is that each demand must be compromised in order to arrive at a buoyant, stable, and workable ship. Furthermore, it should be axiomatic that there must be employed afloat much larger factors of safety than are needed in shore design.

Just as in shore establishments, afloat there are steam plants, Diesel plants, combination steam and Diesel, and a constantly increasing use of electricity for the distribution of power to distant units, and for reduction gears.

For the main propulsive units, which account for 80 per cent or more of the power utilization, there are steam plants driving turbines through mechanical reduction gears; steam plants driving generators, which in turn drive the propeller through a motor or so-called electric drive; the straight Diesel drive; the Diesel drive through mechanical reduction gears; and the Diesel drive through electrical reduction gears, if they may be so termed. The race between the Diesel and the turbine is so close, from the standpoint both of reliability and economy, when the 20-year life of a vessel is considered, that the choice between them becomes largely a matter of personal preference. The same condition is not quite true of the choice between mechanical or hydraulic reduction gears and electrical coupling. There is no question but that electric losses of such connections are somewhat greater than the friction losses of well-made reduction gears. On the other hand, the author* is of the opinion that the flexibility and the elimination of vibration inherent in the electric gear more than compensate for the difference in efficiency in the case of many merchant ships and afford the electric connection much attraction for military purposes.

In departments of the ship other than the engine room, there seems to be slight justification for any but electrical equipment. Electric winches, electric steering engines, electric galleys, because of the flexibility of electric-power conduits, as compared with the awkwardness and risks of conducting steam about a ship, have left the steam-driven winch and the oil-fired galley range in the limbo of the past.

* From a paper "Some Problems in the Design and Operation of Merchant Vessels," by Robert C. Lee, published in the *Transactions* of The American Society of Mechanical Engineers, February 1940, pages 63-74.

Note on Earnshaw's Theorem

LEWI TONKS

Many have seen the "electromagnetic levitator" in the General Electric Company's "House of Magic" demonstration lectures. In this demonstration, an aluminum disk is stably supported in an alternating magnetic field under the repulsive force between the induced eddy currents and field.[5] Another and related problem is reflected in several recent and serious, but inevitably futile, attempts to achieve stable suspension in space under the forces of permanent magnets alone. This article sheds further light on the basic theory involved, which was formulated a century ago by Samuel Earnshaw and seems quite largely to have been overlooked.

EARNSHAW'S THEOREM as quoted by Maxwell[1] states that: A charged body placed in a field of electric force cannot be in stable equilibrium. In general it has received rather scant attention, and Earnshaw himself has been neglected, by those judged to be his compatriots, in the "Encyclopedia Britannica."

The chief theoretical importance of the theorem has arisen from its bearing on the static model of the atom, for it proves the impossibility of such an atom composed of charges that exert Coulomb forces on each other.

This may explain the partial neglect which the theorem has suffered; the static atom has long since ceased to be an issue. But the recent development of ferromagnetic materials having enough remanence and coercive force so that the repulsion of one permanent magnet for another is greater than its weight lends fresh importance to that theorem. These magnetic forces are of a magnitude to interest the engineer, who may look upon them as a way of overcoming gravity and attaining the free stable suspension of bodies in space. It therefore becomes necessary to point out that all such attempts to use simply the force between permanent magnetic poles, or between poles and a fixed field are doomed to failure because the magnetic field obeys the same law as the electric field.

The restrictions are even narrower than this, for no flexible assemblage of magnetic poles, in which readjustments in position of the poles in the group can occur, can be stable in either a fixed field or in the field from another such assemblage. The proof of this statement is implicit in Maxwell's proof, but it is worth while briefly to recapitulate this demonstration in terms of magnetic poles instead of electric charges and to point out the relation of the theorem to two devices that achieve the stable suspension of bodies in free space.

Consider two assemblages of poles, I and II. Let the m poles of assemblage I be interconnected by any system of ropes and pulleys, springs, rods, levers, etc., subject only to the restriction that the force field shall be conservative. Let the same be true of the n poles of assemblage II.

Following Maxwell's treatment, we first suppose the poles within I to be temporarily immobilized, and the same for II; second, we suppose that both I and II are prevented from rotating and only allow translation of I relative to II. By applying Laplace's equation to the magnetic potential of assemblage II at the points where poles of I are located, it appears that there are always directions of displacements for I in which the initial change in the potential energy M is a decrease. That is, $\partial M/\partial r$ is negative infinitesimally close to the position of I if not at the position itself. Hence I tends, when slightly displaced, to move in such a direction under the force $-\partial M/\partial r$, and any equilibrium is unstable. Instability is therefore all the more present when the two assemblages are free to rotate.

Now let I move a distance δr in such a direction. Then let us release the temporary constraints from I and II so that the poles within each assemblage can move. Such motion will lower the potential energy by an amount that may be denoted by $C\delta r$. Accordingly, the total increase in potential energy accompanying the displacement δr is $[(\partial M/\partial r)-C]\delta r$ so that the restoring force is $(\partial M/\partial r)-C$. Since C is positive, the instability represented by the negative $\partial M/\partial r$ is *increased* by the flexibility in the two groups of poles.

It should be noted that the presence of induction effects of the field on the poles is covered by this treatment, for these changes can be simulated by the proper elastic connections between infinitesimal poles. In addition, the presence of a gravitational field acting on one assemblage alone, as is the case if the other assemblage is attached to the earth, cannot create stability, for the gravitational field itself obeys the inverse-square law.

Any restraint between the two assemblages of poles of course, may give stability. In particular, the reduction of the problem to two dimensions, as by Ewing with his floating magnets, immediately makes stability possible, because confining one assemblage to motion in a plane is a restraint. We need only arrange that $\partial M/\partial r$ is positive for δr in the plane and negative for δr perpendicular to it, and confinement to the plane will supply the stability that the magnetic field alone lacks.

Two types of stable free suspension using magnetic forces are known to the author, and it is of interest to note their relation to the foregoing proof. An example of the first type [2–4] employs an electromagnet (or coil) to support a permanent magnet, or soft-iron armature, the strength of the electromagnet being continuously and automatically readjusted by a control system to hold the permanent or induced magnet at a fixed level. The necessary changes in pole strength are in the opposite sense to the induction effects which have already been mentioned. Since those induction effects correspond to a positive value for C, the forced effects correspond to a negative C, which, if large enough, can achieve stability.

The second device is the electromagnetic levitator,[5] in which an aluminum disk is stably supported in an alternating magnetic field under the repulsive force between the

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induced eddy currents and the field. Here the suspended "poles" are solely those produced by circulating currents. Although this situation is far more complicated, we can at least recognize that the Coulomb law no longer applies to the floating disk, for the closer approach of disk to field coils increases the eddy currents so that the repulsion increases faster than according to Coulomb's law. And small shifts of the disk into other parts of the field cause the creation of new "poles". In this case as in the previous one, the changes in pole strength correspond to negative (magnetic) induction.

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A Modern Aspect of Engineering Education

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An engineering education will fail in its purpose if it gives mere formulaic information; it must build a man who can accept the responsibilities a modern world thrusts upon him, says this engineering-college dean who describes the program established at one university to give the young engineer not only the technical knowledge his profession demands, but also that broader education required to enable him to meet the demands of this modern world.

THE ENGINEER is regarded in the world of today as a man who has accomplished miracles. No one would criticize him for lack of imagination or deficiency in ability to develop mechanical or technical works. Whatever criticism is levied against him is levied from the standpoint that he has not applied the same skill that he has used for the solution of technical problems to the social, economic, and human problems that affect our life today. Yet, it is incumbent upon him that he do so if the definition that formerly hung in the library of the Engineering Societies Building in New York City is a valid one. It places in first position the importance of directing men as it proclaims: "Engineering—the art of organizing and directing men and of controlling the forces and materials of nature for the benefit of the human race".

In the following discussion it is this broad conception of the realm of the engineer that must be kept in mind in contradistinction to the more narrowed concept of the technician or the designer engaged upon routine work or the man engaged in ordinary testing. We must consider that the real engineer of today is a man who thoroughly understands not only the fundamental technical information pertaining to his profession, but also is educated in a much broader field. Only then can he cope with the social, economic, and psychological factors which ever will present themselves when various tasks are brought to him for his consideration. What wonder, therefore, that the engineering educators of today look critically at the curricula of the various engineering institutions of learning in an effort to determine what might be done so that the engineer shall be considered more than a technical expert. No profession has scrutinized more carefully and critically the educational methods that apply to the men who contemplate entrance into its ranks than has the engineering profession. In 1922, after many years of discussion, an extensive investigation of the educational methods in engineering was begun under the auspices of the Society for the Promotion of Engineering Education. It is impossible to attend a meeting today of any of the national professional engineering societies without at least some reference being made to engineering education.

Society Criticizes the Engineer

These references are of a varied nature. Sometimes the engineer is accused of being so interested in his professional work and in doing things of a technical nature that he has neglected the duties of citizenship. Sometimes he is accused of being far more interested in mathematical and physical phenomena than he is in the cultural, social, and human problems of the world about him. We are told that he is lacking in personality, in social consciousness, in artistic taste, in appreciation of financial problems, and in foresight pertaining to human adjustments. In fact, he is frequently blamed for many of the present ills of modern society.

We cannot accept these criticisms as valid, for in every worth-while movement today, the engineer does take an active part. We cannot agree with the statement that the engineer must also be a banker, a lawyer, a sociologist, as

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Essential substance of an address presented at the AIEE Southern District meeting, Miami, Fla., November 28–30, 1938; subsequently revised and brought up to date.

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well as a good engineer. We do not expect the economist to know engineering. The lawyer is hardly expected to solve engineering problems. The sociologist does not build bridges. Each of these men has his field; and if one is to become expert in any field, he cannot thoroughly know all the rest. This applies to the engineer as well. The engineer designs and supervises the construction of a great bridge or a large dam, a power plant, a system of roads, a transmission line, a radio station; or he takes an active part in many of the major activities that come definitely within the province of his profession. If he is to become sufficiently expert in the technical phases of his subjects, if he is to secure the experience, the imagination, and the ingenuity that will help build these wonders of our age, how can we expect that he can become adept in those other professions which also must take a lifetime of earnest effort, of hard work, and much study to master them.

Purpose of an Engineering Education

What then should be the purpose of an engineering education? Surely it must be more than just another step in the student's educational program, more than just another step between high school and professional life. It comprises probably the greatest period of transition in a man's development. Shall it be along narrow lines to fit him quickly into the industrial world? Then shop courses and minute specialization will quickly assist the young man to step into production in industry. It must be broader than this. It should prepare the young man for the tomorrow of his whole life. It should be the foundation upon which must rest not merely the floor above, but the entire superstructure. An engineering education will fail in its purpose if it gives mere formulaic information. It must build a man—a man who can accept the responsibilities a modern world thrusts upon him. Success in his life's vocation definitely will depend on his ability to assume these responsibilities. Those graduates of our institutions who wonder why success does not come to them—are they not frequently unable to cope with the demands of the present-day world? The engineer obviously must learn and know the technical matter that is unique to his profession; but if more than mediocrity is to be his reward, then he must develop himself in a broad manner so as to be able to solve problems by weaving together technical data with social, economic, and psychological factors. What is applicable to engineering is likewise applicable to the practitioner in many other professions. No problem is solved until its solution is tested by performance and the new problems brought about by its innovation have been solved. This is an endless chain, and the adjustments must be many—and he who is to be the "captain" must be the superman, indeed. Modern education should take cognizance of this, and no program should be adopted that fits a man into a groove that is too narrow. Technical knowledge alone cannot suffice.

There are certain broad fields of knowledge with which all professional men should be acquainted. Every preprofessional course should demand a reasonable conception of the correlated problems in the fields of the social, physical, and biological sciences. Add to these an appreciation of the so-called humanities, an ability to express oneself well in written and spoken English, and a conception of mathematical relations and we have a basic training that will form a foundation for many types of superstructures.

Analyzing the Entering Student

A question arises at once: Can all students benefit from such a program? Perhaps not. Certainly any man having the ability to benefit from a college education should benefit from a program that makes not for narrow specialization and a limited outlook, but which gives him a conception of not only his chosen field but also the adjacent territory as well. Perhaps to the college this question will also emphasize the need for a greater scrutiny of entering freshmen so that those who probably would derive little advantage from the time spent at the university might be shunted into other paths. Many state institutions find it difficult to discriminate against state high schools, even though they have found that from some of them come students so poorly prepared in basic subjects required of university students, that they fail, or—and this is probably worse—that they stumble through a four-year course barely passing in a majority of the work. Sometimes this is due to the student's lack of ability, but not always. Where to place the blame for this we are not at this moment to determine, but that there is a need for educational guidance is definitely shown.

Yet college procedure is highly stereotyped. Few colleges pay much attention to the entering student except to make sure that he is a high-school graduate. He must choose his career on entering a university, even though he is not prepared to do so. Usually his choice of curriculum is based upon hit-or-miss methods. How much better would it be if the student had an educational background that would give him general information of the several fields of knowledge so that he might more intelligently select his vocation. Thus, educational guidance and vocational guidance are closely related. Both must be based upon definite information of the knowledge and aptitudes of the student. This can only be secured by thoroughly examining the entering student and by closely following him during his educational program. Should not the college use some means of "inspecting" the entering "raw material"? Should all material be accepted regardless of whether or not it is suitable? Should all material go through identical processes? Obviously not! Poor incoming material, hit-or-miss methods in selecting a career, coupled with a narrow technological training will seldom produce more than "slide-rule artists" and technicians.

The various curricula of the engineering institutions of the United States are indicative of many approaches to overcome these problems, and while it would be well to consider many of them, this article deals with a relatively new one which has been introduced at the University of Florida. It gives a new approach to some of the problems that have confronted us, and it seems to give an answer to many of the criticisms that have been levied against engi-

neering educators. In it will be found a definite attempt to prepare the student not only for entrance to the engineering profession by giving him a well-rounded technical education, but also to give him many subjects that tend to make for better citizenship and for an appreciation of the problems of the modern world.

Adjustment of Curricula to Meet Student Needs

Certainly it does not have for its purpose the turning out of more engineers—but rather, better engineers. There will be found some application of what might be called "engineering principles" in the selection of "raw materials" and in what might be called the "operation of the plant". Every incoming student to the University is given an examination. Some of them are told that it is improbable that they will benefit from a college course and are advised not to matriculate. The remainder, through individual conferences with the dean or his representative, secure educational guidance in planning their courses. This corresponds to what in industry would be an "inspection and selection of raw materials".

Inspection of the entering students is made through a series of comprehensive examinations, in many cases even before he leaves high school. Results of such examinations together with the high-school record gives much information that is of value in analyzing the new student. The student who has done only mediocre work in high school is given courses in "man and the social world", "man and the physical world", English, "man and his thinking", and "elementary mathematics". If he shows aptitude and a fair knowledge of the physical sciences and of mathematics some of these courses may be omitted. Thus, for superior students adequately prepared there is no duplication of material already learned; but for the student not so well prepared, the survey course in the physical sciences allows better work to be done in the advanced courses. The survey course in mathematics does the same.

Thus, as the result of the inspection of the incoming "raw material," only that which is ready is built at once into the finished product. The rest is further processed before being utilized in making the final product. While for those men who have chosen a career and who have both the necessary aptitude and information there is no delay, for others the foundation must be prepared before the superstructure can be placed on it.

Then, too, since the superior student can forge ahead more rapidly than the average student, he is permitted to do so. In his sophomore year a course in the humanities and one in the biological sciences are given him. In consequence, at the end of the sophomore year the superior student has received the basic training in the fundamentals of engineering (English, calculus, chemistry, physics, drawing, descriptive geometry, and an engineering elective course) and in addition he has secured courses in the other broad fields of learning. Therefore, he has utilized his superior ability for securing some liberal education coupled with the necessary pre-engineering information that he must have for pursuing an engineering career.

But what about the nonsuperior student, the student who is not so well prepared, the student who has not determined his future vocation? These men will require an additional year, but this is not extra time required for making up failures. In some instances this time is devoted to securing better preparation for the courses in mathematics and the physical sciences which follow. In others the load is reduced and the student goes ahead at a less rapid pace. In each instance the student's needs are considered and he is given educational guidance as he proceeds.

Educational Guidance Parallels Vocational Guidance

Closely allied to educational guidance comes vocational guidance; and although there is a close relationship between educational guidance and vocational guidance, they are not the same. Frequently, a student comes to a university with an apparent desire to enter a particular curriculum. He may wish to become an engineer because someone has told him of high remuneration involved, or the glamour connected with some parts of this profession. As to his aptitude and general fitness for this profession, that is left to chance. From interviews with entering students it has been quite surprising to find what little reason, judgment, and common sense the student uses in the selection of his life's work. But most vocational guidance supposes that the student has sufficient knowledge to plan his career. Unfortunately, he usually has not. The broad education that students receive during their first few years allows them to become far better acquainted with various forms of man's endeavor and they then can make a much more intelligent choice of their life's work. The sorting process previously mentioned thus is continued.

Some of the material finds its way to the colleges of engineering, business administration, agriculture, and others. Certainly, many who thought they would like to become engineers have found that they probably would prefer work in other fields. Still others who thought they would not like engineering now find a preference for this work. The case of one student in particular who said he had a dislike for engineering, on entering the University, is an example of this. His dislike was based primarily upon a serious deficiency in mathematics and physics. Yet, this same student showed excellent aptitude for these courses in the general college and will probably make a successful engineer. His dislike for mathematics and physics was not due to lack of ability in these fields, but was due to poor preparation—perhaps due to poor teaching before coming to college.

This sorting process thus allows differentiation to be made between various types of students and enables adjustments to be made better to qualify them for fields in which they are best fitted. Through frequent conferences with members of the faculty, students are given vocational guidance only after some educational groundwork has been laid, so that an intelligent decision of a vocation based upon knowledge can be made.

A Terminal Point at the Halfway Mark

This sorting is carried even further. It is recognized that after two years in college some men might best terminate their collegiate program and go home. However, at most universities there is a certain stigma attached to the man who does not complete his college course and receive a degree. Now, at the end of the two-year general-college program at the University of Florida there is a definite terminal point, and those who reach it receive a certificate—an honorable discharge for those who leave. It gives them an easy way out. In other words, there is an inspection halfway through the process and some by-product recovery.

Mere graduation from the general college, however, is not sufficient for entrance into the upper division of the college of engineering. The student must satisfy the entrance committee of the engineering college that he is qualified to pursue a curriculum leading to a degree in engineering. Students who have secured mere passing grades in the lower division are not admitted to the engineering college. Students who have slight deficiencies may be admitted on probation. The student thus is given a stimulus to do better work. Mere "getting by" is definitely discouraged. Students, therefore, cannot be satisfied in just passing courses, but often prefer to proceed more slowly and so do work of a better quality. Many men now on entering college plan from the very beginning on a five-year college program.

It would be a mistake to assume that barriers are thrown in the way of those students who show a definite interest in engineering, and who show they have the required aptitude as the result of the entrance examination. Those students who have shown knowledge and aptitude in the sciences and mathematics are allowed to proceed directly with prescribed engineering subjects. Such men take heavy schedules and can complete the entire engineering course in four years. Their curricula will have included courses in the social and economic phases of modern life without in any way sacrificing instruction in the technical aspects of engineering. Five years, however, are required by most students to secure an engineering degree, but this has been true for most students even with the curricula in effect many years ago.

Modern Methods for Increased Efficiency

The courses in the general college have been carefully planned, and improved pedagogical methods are in use. Every attempt is made to have the student use his initiative. The amount of material covered in a particular course by different students varies greatly, depending primarily upon their interests and abilities. Grading is not on the basis of mere attendance, but is primarily based upon achievement—comprehensive examinations being used in many courses for making such measurements. In fact, the student may register for some examinations without attending the courses, and some students find it possible to pass a few courses in this manner. Each student is given considerable latitude in developing himself according to his own individuality.

Although the last two years of the engineering program do not differ materially from the standard programs of other engineering colleges, the influence of the educational program outlined herein definitely is felt in the upper-division work. It seems that the quality of the work is better. Only students who show reasonable aptitude and who can demonstrate by examination that they are in a position to benefit by a course in basic mathematics are assigned to this course. Most of the students of the type who formerly just "got by" are weeded out, and a larger proportion of those taking basic mathematics and calculus pass with grades above the mere passing grade. This improved work in mathematics would necessarily be reflected in the courses that follow in engineering.

In the upper division more and more efforts are being made to place courses on a project basis, and to give the student more opportunity to develop individual resourcefulness. Courses are planned realizing that an engineer first of all must know the technological material that is basic to his profession. Then upon this must be built that philosophy of engineering which should enable him to handle not only materials and methods, but also men and money. Courses, especially in the general college, are at the present time all in a formative period, and each day brings new changes—changes which it is hoped will give industry men with a good knowledge of fundamental engineering; men with a thorough knowledge of engineering technology; men well versed in the philosophy of our profession; but above all, men who have a social consciousness so that they may become good administrators and good citizens, for otherwise they are mere "Frankensteins" and their work will come to naught.

In the new program the work of the college does not stop when a man is graduated, but the college will attempt to give what might be called postgraduate guidance. While in the past this has been limited almost entirely to an attempt to secure employment, this will now go further and the graduates will receive assistance in adjusting themselves to the industrial world, and assistance in continuing their education after graduation. As the engineering educator finds himself less and less occupied with the problems of the entering student, he can devote more and more efforts to the alumni, and here it seems beneficial work can be done.

The world today challenges the engineer. It is not satisfied that he bring his brain children into being; it demands that he guide and control them. The works of the engineer are all about us, but the control of these works, for the most part, is in the hands of other men. The engineer of tomorrow, therefore, must be educated broadly enough so that not only can he guide the destiny of his own work, but also in this modern scientific age he must perhaps become the guide of the world about him.

The program that has been described attempts to give the young engineer not only the technical knowledge his profession demands, but also that broader education in the arts, humanities, and associated sciences, which it is hoped will fit him not only for his life's career, but also for the other duties that the world now expects of him.

Of Current Interest

Industry • • • •

$200,000 for Arc-Welding Papers

According to announcements currently being distributed by the James F. Lincoln Arc Welding Foundation of Cleveland, Ohio, a total of 458 cash awards amounting to $200,000 will be made to the authors of winning papers in an arc-welding prize paper contest which opened January 1, 1940, and which is scheduled to run for two and a half years, until June 1, 1942. By its own statements:

"The object and purpose of the James F. Lincoln Arc Welding Foundation is to encourage and stimulate scientific interest in, and scientific study, research, and education in respect of, the development of the arc welding industry through advance in the knowledge of the design and practical application of the arc welding process. . . . Many of the benefits of progress in recent years have been due to the scientific development and application of arc welding. Arc welding so lowers the cost of manufacture that products which were luxuries yesterday are commonplace today. Further progress in developing and applying arc welding in the vast undeveloped field of its possible application will transform the extravagances of today into the common good of tomorrow."

Top prize for the best all-around paper is announced as amounting to $13,700; at least 223 honorable mentions will receive $100 apiece.

For the classification of subject matter, 12 industrial classifications have been established: automotive, aircraft, railroads, watercraft, structural, furniture and fixtures, commercial welding, containers, welderies, functional machinery, industry machinery, and maintenance. These 12 classifications have been subdivided into a total of 46 divisions to broaden the basis of possible entry into the competition.

Although electric arc welding is emphasized in the literature, it is understood that it is the desire of the Foundation to bring out social benefits and possibilities for better or more economical products resulting from arc welding as a process, rather than to emphasize in any way mere magnitude of any one arc-welding application.

A 48-page illustrated booklet descriptive of the program is said to be available on request to the James F. Lincoln Arc Welding Foundation, Post Office Box 5728, Cleveland, Ohio.

Technical Magazine in Spanish. To acquaint engineers and industrialists in Latin American countries with technical developments in the United States, a monthly magazine, "La Ingenieria e Industria en los Estados Unidos" (Engineering and Industry in the United States) has just begun publication. Issued in Spanish by the Pan-American Economic News, Inc., 80 Broad Street, New York, N. Y., the new magazine is interested in receiving articles suited to its needs from AIEE members and others.

From A E C • •

ITEMS appearing under this heading are from the news service of American Engineering Council.

New Quarters

Effective February 15, American Engineering Council shifted its offices in Washington from the old quarters which it had occupied since 1922 to a new location at 919—17th Street, N.W., where it will occupy a building jointly with the American Forestry Association and immediately adjoining the Army and Navy Club.

While the primary motive for the move was the expanding needs of the American Council on Education, which had been sharing the building at 744 Jackson Place, AEC itself will realize a number of benefits that will more than offset the trouble of moving. The new offices are fully as convenient, being located only a block distant from the old, and will provide facilities better adapted to the needs of Council, which requires much storage space for the valuable records accumulated during the past 20 years. These are now more readily accessible. In addition, there will be a distinct saving in rental charges, making it possible to devote a larger proportion of the annual budget to productive activities.

Education • • •

Engineering for Doctors. Summarizing the latest reports of the Harkness family's Commonwealth Fund's philanthropic activities in the field of U. S. public health and medical research, *Time* magazine for January 22 points out that "One interesting award sends a man from a physiological laboratory to a school of engineering so that he can bring back from hydraulics and mechanics principles and techniques applicable to the study of blood pressure, blood flow, and the like."

Power Conference. Sponsored annually by Armour Institute of Technology for industrialists and educators all over the country, the Midwest Power Conference will be held this year at the Palmer House, Chicago, Ill., April 9 and 10. The conference is conducted with the co-operation of Iowa State College, Michigan State College, Purdue University, State University of Iowa, University of Illinois, University of Michigan, University of Wisconsin, the Chicago Sections of the AIEE and American Society of Mechanical Engineers, the Western Society of Engineers, and other engineering societies. Subjects of special sessions include small power plants, electrical transmission, power-process, fuel problems of power plants, and hydro power. L. W. W. Morrow (A'13, F'25) regional editorial director, McGraw-Hill Publications, Chicago, will be speaker at a joint luncheon of the conference and the AIEE Chicago Section on April 10.

Other Societies •

Cumulative Index. A cumulative author and analytical subject index of volumes 1–10 of the *Journal* of the Acoustical Society of America, October 1929 to April 1939 inclusive, has recently been issued for the Society by the American Institute of Physics. The volume also includes author and subject indexes of contemporary literature on acoustics, as listed in the *Journal* 1937–39. Copies of the index may be secured from the publications manager, American Institute of Physics, 175 Fifth Avenue, New York N. Y.; price $3.00 per copy.

Future Meetings of Other Societies

American Chemical Society. Annual meeting, April 8–12, 1940, Cincinnati, Ohio.

American Institute of Chemical Engineers. 32d semi-annual meeting, May 13–15, 1940, Buffalo, N. Y.

American Physical Society. 234th meeting, April 25–27, 1940, Washington, D. C.

American Society for Testing Materials. 43d annual meeting, June 24–28, 1940, Atlantic City, N. J.

American Society of Civil Engineers. Spring meeting, April 17–19, 1940, Kansas City, Mo.

American Society of Mechanical Engineers. Spring meeting, May 1–3, 1940, Worcester, Mass.

Semi-annual meeting, June 17–21, 1940, Milwaukee, Wis.

Association of Iron and Steel Engineers. Annual Spring Conference, April 1–2, 1940, Cincinnati, Ohio.

Edison Electric Institute. Annual meeting, June 3–6, 1940, Atlantic City, N. J.

Electrochemical Society. Spring meeting, April 24–27, 1940, Wernersville, Pa.

Midwest Power Conference. April 9–10, 1940, Chicago, Ill.

Society of Automotive Engineers. Summer meeting, June 9–14, 1940, White Sulphur Springs, W. Va.

Letters to the Editor • • •

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

The Use of the Millibar In Weather Bureau Reports

To the Editor:

The engineering societies have cause to object and protest to the current action of the United States Weather Bureau in putting out barometric data in terms of millibars instead of inches of height of the mercury barometric column on the following grounds.

This change is the antithesis of standardization in that it replaces an ancient and universally used standard of this and other English speaking countries by another of limited acceptance which offers no advantages from the point of view of logic, scientific legitimacy, or convenience in use, except possibly to a small coterie of meteorologists interested in international comparisons of such data. Engineering standards and rules are expressed in terms of barometric height. This encroachment of a Government Bureau on a standardizing matter, which is particularly in the province of the engineering societies, should be resisted.

The introduction of the millibar unit renders impossible the direct comparison of Weather Bureau data with the readings of all barometers. This lessens the value of the service to the public, which is ostensibly the object for which the Weather Bureau spends a considerable amount of public funds. Vacuum gauges as well as barometers are graduated in inches of mercury column.

The procedure as described in an official letter dated January 26, 1940, is as follows: "Mercurial barometers used by the Weather Bureau are graduated in inches. Readings made in inches are converted into millibars before being reported. The millibar is internationally employed for reporting barometric pressures."

In Form 4090, "The Use of Millibars" the following statements occur: "In earlier years it was customary to express atmospheric pressure in inches denoting height of the mercury column in the barometer. Since the inch is a unit of length, and not a unit of pressure, the use of inches for expressing atmospheric pressure is unsatisfactory for modern purposes. Several years ago the millibar, which is the standard unit of pressure, was adopted for aerological observations, and since then its advantages have resulted in its adoption by nearly all countries for use in expressing barometric observations taken on ships at sea as well as at regular weather stations on land.

"Because of the delay incident to converting millibars into inches, with the increasing number of weather reports from ships at sea and from Canada and other countries, the Weather Bureau on July 1, 1939 adopted the numerical code which uses millibars and began publishing these units on its Washington weather map. This permits speedier handling of its reports and greater accuracy in analyzing weather situations for the purpose of issuing weather maps, forecasts, and advices."

Fault can be found with the foregoing statement in a number of particulars, some of which are quite obvious. Note should be made however, of the statement that the millibar is "the standard unit of pressure." This statement is inaccurate. There are various standard units of pressure such as the pound per square inch, and the height of the barometric column. The millibar is a derivative of the theoretical centimeter-gram-second system of units which has never entered into general practice in science and engineering, and hence cannot be called the standard system. The international meteorologists may have agreed to exchange data in terms of millibars. No fault can be found with this, but it does not make the millibar the standard unit of pressure.

The plea is made that the use of the millibar tends toward greater accuracy. It is difficult to see why multiplying the readings of an instrument by a constant makes them more accurate. Such an operation even introduces the chance of a numerical error.

In the conversion table from millibars to "inches" the Bureau follows a practice which by implication it elsewhere condemns. This table makes no statement as to the value of the gravitational constant on which it is based. Such looseness of terminology and incompleteness of statement do not add to the strength of the Weather Bureau's argument.

The foregoing considerations suggest the thought that the Weather Bureau is willing to subordinate the interests and convenience of readers of barometers and students of its own charts and tables to its own facility of operation.

It is urged that the engineering societies should use their powerful influence to resist, in behalf of engineers and of the public affected, all tampering with existing, generally adopted standards, except for such compelling reasons as do not exist in the present case.

CLAYTON H. SHARP (A'02, F'12)

(Formerly President, United States National Committee, International Electrotechnical Commission)

Obtaining Test Constants for Induction Motors

To the Editor:

In manufacturing practice it is often necessary to obtain the constants of an induction motor from test measurements on a finished machine. This may be for the purpose of fault location, finding manufacturing errors, or for duplicating the performance of a completed machine with another set of punchings.

Such a method was given by C. G. Veinott for single-phase motors in ELECTRICAL ENGINEERING for December 1935, page 1302. Another procedure is given in the AIEE standards for polyphase induction motors. These involve accurate readings of slip which are not always convenient to take. They also have the objection that the leakage reactance is treated in the same way as an ordinary impedance. Because of this, they lead to a certain amount of error which becomes more marked as the number of poles increases or the frequency decreases.

Because of their convenience and the fact that they seem not to be generally known, there will be given in outline a method alternative to that of Veinott for single-phase, and another for polyphase motors. In the derivation, core loss and saturation are neglected.

Readings Required: Single and Polyphase.

1. D-c resistance of primary in ohms per phase $= r_1$.

2. No-load: $\dfrac{\text{volts}}{E_0} \Big| \dfrac{\text{amperes}}{I_0} \Big| \dfrac{\text{watts}}{W_0}$

(all per phase).

3. Locked: $\dfrac{\text{volts}}{E} \Big| \dfrac{\text{amperes}}{I} \Big| \dfrac{\text{watts}}{W}$

at rated or reduced voltage and rated frequency, all per phase.

(*a*) Calculations: single-phase:

$$Z = \frac{E}{I}, \quad R = \frac{W}{I^2}, \quad X = \sqrt{Z^2 - R^2}$$

From the theory of the single-phase motor;

$$i_m \cong \frac{2 - K_r}{2} I_0$$

Assume a value for K_r and correct later. This is done by repeating the work that follows two or three times until it converges to its final value.

Magnetizing reactance with open rotor = mutual + primary leakage reactances,

$$X_0 \cong \frac{E_0}{i_m}$$

$$K_r = \frac{X_0 - X}{X_0}$$

$$a = \frac{R - r_1}{X}$$

$$b_1 = \frac{1 - (1 - K_r)(a^2 + 1)}{K_r}$$

Leakage reactance,

$$X_{\text{corrected}} = b_1 X$$

Calculate new K_r and repeat until convergence.

$$b_2 = \frac{1}{K_r}\left[\left(\frac{X}{Z'} - \frac{Z'}{X_0}\right)^2 + \left(\frac{R - r_1}{Z'}\right)^2\right]$$

$r_2' = \dfrac{R - r_1}{b_2}$ = crossfield theory value of rotor resistance. Includes skin effect if X does not change much from locked to idle conditions.

The revolving field theory value is one-half of this.

If desired, b_1 and b_2 can be plotted against a for different values of K_r.

(*b*) Calculations: polyphase:

$$Z=\frac{E}{I}, \quad R=\frac{W}{I^2}, \quad X=\sqrt{Z^2-R^2}$$

Magnetizing reactance = sum of mutual and primary leakage reactances,

$$X_0 \cong \frac{E_0}{I_0}$$

$$K_r=\frac{X_0-X}{X_0}$$

Let

$$a=\frac{R-r_1}{X}$$

then

$$b_1=\frac{1-(1-K_r)(a^2+1)}{K_r}$$

$$X_{\text{corrected}}=b_1X$$

$$K_{r_{\text{corrected}}}=\frac{X_0-X_{\text{corrected}}}{X_0}$$

Physically K_r is equal to the coupling coefficient, $\frac{M^2}{L_1L_2}$.

When r_1 is considered as external series resistance (B. De La Tour),

$$\frac{K_rE}{(1-K_r)X_0}=\frac{K_rE}{X_{\text{corrected}}}=\text{circle diameter.}$$

Let

$$Z'=\sqrt{(R-r_1)^2+X^2}$$

Then

$$b_2=\frac{1}{K_{r_{\text{corrected}}}}\left[\left(\frac{X}{Z'}-\frac{Z'}{X_0}\right)^2+\left(\frac{R-r_1}{Z'}\right)^2\right]$$

$$r_2=\frac{R-r_1}{b_2}=\text{rotor resistance.}$$

(Includes skin effect if X is about the same at no-load and short-circuit.)

When X is known it can be broken up into components x_1 and x_2 for classes A, B, etc., as suggested in the induction motor standards.

Roughly,

$$x_1 \cong x_2 \cong \frac{X}{2}$$

or better,

$$x_1 \cong x_2 \cong \frac{1-\sqrt{K_r}}{1-K_r}$$

As no workable method for obtaining x_1 and x_2 from test is known, and since the behavior of a motor is largely independent of the distribution in leakage between primary and secondary, this division is sufficient for most purposes. This division is not necessary for drawing the circle diagram.

A. F. PUCHSTEIN (A'20, M'27)

(Consulting Engineer, Robbins and Myers, Inc., Springfield, Ohio)

Library

OPERATED jointly by the AIEE and the other founder societies, the Engineering Societies Library, 29 West 39th Street, New York, N. Y., offers a wide variety of services to members all over the world. Information about these services may be obtained on inquiry to the director.

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

AT&T, THE STORY OF INDUSTRIAL CONQUEST. By N. R. Danielian. New York, The Vanguard Press, 1939. 460 pages, maps, tables, 10 by 6 inches, cloth, $3.75. A case history, covering the development, management, faults, and virtues of the corporation. Chief sources of the information are the reports of a Federal Communications Committee investigation, which, although of public record, have never been published. A large list of references to this material is given.

AIRCRAFT, RADIO, AND ELECTRICAL EQUIPMENT. By H. K. Morgan. New York and Chicago, Pitman Publishing Corporation, 1939. 374 pages, illustrated, 9 by 6 inches, cloth $4.50. The fundamentals of electricity and electrical equipment are presented, present-day equipment is described, and the topics of radio waves, static, direction-finding, ultrahigh frequencies, inspection, and maintenance are discussed. Many schematic diagrams. Questions follow each chapter, with answers grouped in an appendix.

DYADIC CIRCUIT ANALYSIS. By A. Pen-Tung Sah. Scranton, Pa., International Textbook Company, 1939. 415 pages, diagrams, etc., 9 by 5 inches, fabrikoid, $4.50. Based on the work of Gibbs and Wilson, the first four chapters explain the elements of dyadic algebra and the application of these methods to the solution of problems involving three-phase circuits. In the remaining four chapters specific problems, such as transformer banks, transmission lines, and induction and synchronous machines, have been studied from the dyadic viewpoint.

THE ELECTRIC POWER ENGINEERS' HANDBOOK. By W. S. Ibbetson. New York, Chemical Publishing Company; London, E. and F. N. Spon, 1939. 241 pages, illustrated, 9 by 6 inches, cloth, $5.00. This manual for the efficient control and care of all kinds of electrical machinery presents basic theory, description, and directions for the proper operation and maintenance of motors, generators, converters, and rectifiers. There are two chapters on faults, breakdowns, and testing.

THE MATHEMATICAL THEORY OF HUYGENS' PRINCIPLE. By B. B. Baker and E. T. Copson. Oxford, England, Clarendon Press; New York, Oxford University Press, 1939. 155 pages, diagrams, etc., 10 by 7 inches, cloth, $4.25. Deals with the mathematical theory of Huygens' principle in the propagation of light and of sound waves of small amplitude. It is concerned with the general theory of the solution of the partial differential equations governing these phenomena, detailed application of the theory to the solution of special diffraction problems being discussed only as an illustrative example.

ORGANIZATION AND MANAGEMENT OF PRODUCTION. By W. N. Mitchell. New York and London, McGraw-Hill Book Company, 1939. 417 pages, diagrams, etc., 9½ by 6 inches, cloth, $4.00. The growth of attempts to develop an introductory course in production management for business students in colleges, this book deals with factors in the economic, technological, and geographical environment that determine the general forms of organization of production activities. Also discusses problems encountered in administration work. Reference lists, questions, and exercises.

STATIC AND DYNAMIC ELECTRICITY. By W. R. Smythe. New York and London, McGraw-Hill Book Company, 1939. 560 pages, diagrams, etc., 9½ by 6 inches, cloth, $6.00. Formulates the basic laws of electrostatics, magnetostatics, and electromagnetic theory, by concise vector methods, from the underlying experimental facts. It gives an extended treatment of the mathematical technique for applying these laws to specific problems. Although the theory is completely developed from basic experimental facts, the emphasis is on problems, of which there are several hundred. References are given for additional study.

POWER ECONOMICS FOR ENGINEERING STUDENTS. By R. C. Gorham. Pittsburgh, Pa., Pittsburgh Printing Company, 1939. 310 pages, diagrams, etc., 9½ by 6 inches, cloth, $3.25. Part A presents fundamental concepts and factual information, with general principles applicable to engineering practices for best over-all economy. Part B demonstrates the application of these principles through the use of examples, largely from public-utility practice. References and problems.

THE PAGEANT OF ELECTRICITY. By A. P. Morgan. New York and London, D. Appleton-Century Company, 1939. 363 pages, illustrated, 9 by 6 inches, cloth, $3.50. This history of the development of electrical science is a narrative of the lives and achievements of the outstanding personalities who contributed to its progress. Technical matters are treated simply. A chronology of important dates is included.

PRACTICAL ELECTRICAL WIRING. By H. P. Richter. New York and London, McGraw-Hill Book Company, 1939, 503 pages, illustrated, 8½ by 5½ inches, cloth, $3.00. Explains in plain language for the man who does the work all kinds of light and power wiring for home, farm, and factory. All material is based on the National Electrical Code, and selected tables of data from the code are included.

PRINCIPLES OF INDUSTRIAL ORGANIZATION. By D. S. Kimball and D. S. Kimball, Jr. Fifth edition. New York and London, McGraw-Hill Book Company, 1939. 478 pages, illustrated, 9 by 6 inches, cloth, $4.00. Covers internal organization and procedures of industrial enterprises regarding industry in relation to economic organization in general. New material on effect of recent Federal legislation upon industry has been included in this edition, and all statistical data have been revised.

PRODUCTION MANAGEMENT. By A. M. Simons, reviewed by H. P. Dutton. Chicago, American Technical Society, 1940. 588 pages, illustrated, 9 by 6 inches, cloth, $3.50. Aims to provide a practical approach to the problems of plant location, factory layout, work routing, task fixing, office organization, etc., and to the many phases of hiring, training, and handling of the personnel.

PUBLIC SPEAKING FOR TECHNICAL MEN. By S. M. Tucker. New York and London, McGraw-Hill Book Company, 1939. 397 pages, 8 by 6 inches, cloth, $3.00. Virtues and defects in speaking are brought out through narrative treatment, and working principles to be drawn from these examples are summarized at the end of chapters. Covers diction, organization of material, and platform technique, and includes helps for the technical speaker on using charts, answering questions, and meeting other problems.

THE RADIO AMATEUR'S HANDBOOK. Seventeenth edition, 1940. West Hartford, Conn., American Radio Relay League, 1939. 575 pages, illustrated, 10 by 7 inches, paper, $1.00 in U. S. A., $1.25 in foreign countries; bound, $2.50. Covers comprehensively the amateur short-wave field. The fundamental principles and the design, construction, and operation of transmitting and receiving apparatus are described in detail, including ultrahigh-frequency, emergency, and portable equipment. In addition to revision and new illustrations the subject matter in this edition has been divided into major sections with more extensive subdivision than before.

TRANSPORTATION IN THE UNITED STATES. By T. W. Van Metre. Chicago, Foundation Press, 1939. 403 pages, maps, tables, 9½ by 6 inches, cloth, $3.75. Deals chiefly with railroads, first presenting a history of their development in the United States, with some mention of canals and highways. The second part describes the organization, types of service, and accounting of transportation agencies. The theory and practice of rate-making occupy the third part, and in part IV the regulation of the transportation business is considered. References.

VDI-FORSCHUNGSHEFT 397, July–August, 1939. Ausfluss- und Kraftmessungen an der Beschauflung einer einstufigen Versuchsturbine in Luftversuchsstand. By W. Hartmann. Berlin, VDI-Verlag, 20 pages, illustrated, 12 by 8 inches, paper, 5 rm. This research report describes the setup, procedure, theoretical basis, and results of tests on discharge and power measurements in the blading of an experimental single-stage turbine. The test data are presented in graphs and tables.

MOTOR DICTIONARY. A Complete Dictionary of Motor Terms in Three Languages. II. English-French-German. Compiled by B. R. Dierfeld. Second enlarged edition. London, Massie Publishing Company; New York, Chemical Publishing Company, 1938. 261 pages, 10 by 6 inches, cloth, $4.00. Phrases as well as words are included in this comprehensive three-language dictionary of motor terms. The present section, part II, is alphabetized by the English words, with the corresponding French and German terms added. The revised edition has been enlarged to cover front-wheel drive, independent wheel suspension, the Diesel engine, solid and gaseous fuels, and many recent improvements and innovations in equipment.

RÉSISTANCE MÉCANIQUE DES CONDUCTEURS AÉRIENS. By P. Dévédec. Brussels, Belgium, Alliance Graphique, 1939, 61 pages, diagrams, etc., 11 by 8 inches, paper, 2.20 Belgas. In this pamphlet on the mechanical strength of aerial conductors the author discusses wires under catenary and parabolic loading, shows how to reduce calculations for cables to those for wires, and describes practical applications and actual conditions to be met.

Institute Activities

Increasing Attendance and Interest Maintained at 1940 Winter Convention

CONTINUING the 1939 policy of an enlarged technical program the 1940 AIEE winter convention, held at New York, N. Y., January 22–26, included 18 technical sessions, one more than last year, and eight technical conferences, an increase of three over last year. A brief session on Tuesday afternoon, January 23, for presentation of the Alfred Noble prize, and the special evening program previously announced, which included presentation of the Hoover and Edison medals and a demonstration lecture, were the only nontechnical sessions. Registered attendance, which totaled 1,626, was slightly above the 1939 figure and the highest since 1924. A varied group of inspection trips and the usual entertainment features were included in the program. Statistics on attendance will be found in the accompanying tabulations.

More than 80 technical papers were presented at the sessions, besides conference papers. Since all technical papers, except a few that were noted on the program as available only in advance-copy form, ultimately will be published in TRANSACTIONS, along with their related discussions, no reports on the technical sessions are published here.

MEDAL PRESENTATIONS

As announced in the January issue, the Alfred Noble prize for 1939 was awarded to C. E. Shannon (A'39), who is the youngest person ever to receive the prize, which is limited to authors under 30 years of age. The award was presented at a special session on January 23.

The Hoover Medal was presented to Gano Dunn and the Edison Medal to Philip Torchio, at the special session Wednesday evening, January 24. Details of the presentations, with the text of the addresses, appear on pages 95–102 of this issue. Following the medal ceremonies was a demonstration lecture on "Nuclear Disintegrations," by Doctor Enrico Fermi, text of which appeared in the February issue, pages 57–8.

ENTERTAINMENT AND INSPECTION TRIPS

The customary dinner-dance and smoker were the chief social events of the convention. Attendance at the smoker reached the record-breaking figure of 466; attendance at the dinner-dance totaled 538. The special program of entertainment for women guests included the annual luncheon and bridge party, as well as trips, broadcasts, and other events.

Eight inspection trips were scheduled throughout the week, and in addition tickets to sponsored broadcasts and other events were made available. Attendance at the trips scheduled by the committee totaled 674; attendance at the broadcasts and other miscellaneous events is estimated at about 1,032. Attendance statistics are shown in accompanying tabulations.

Held as usual during winter-convention week was the annual dinner of Eta Kappa Nu celebrating the award of the society's recognition of outstanding young electrical engineers (see the January issue, page 43). About 175 persons attended the dinner, which was held Monday, January 22.

DIRECTORS AND COMMITTEES MEET

The AIEE board of directors met, as is customary, during the winter convention. The national nominating committee also met in accordance with the Institute's bylaws, to select nominees for election to Institute offices for 1940–41. Reports of both these meetings are given in succeeding pages.

Meetings of the following Institute committees were also held during convention week: automatic stations, communication, d-c electric machinery subcommittee, education, electrical machinery, electrochemistry and electrometallurgy, electronics, Lamme medal, membership, planning and co-ordination, power generation, protective devices, relay subcommittee, safety, standards co-ordinating committee 3 subcommittee on insulation testing, standards co-ordinating committee 4, standards for neutral grounding devices, Student Branches, technical committee on sound-level meters, transformer subcommittee, transportation. Following a now established custom, the committee on Student Branches held a luncheon for Branch counselors attending the convention, which was followed by informal discussion.

Brief reports of some of these meetings follow:

Student Branch Committee. At a luncheon meeting to discuss Branch affairs, held in New York January 25, 50 persons were present, including 4 members of the committee on Student Branches, and representing 38 colleges and several industries that have training courses for college graduates. Chairman R. W. Sorensen announced that the new edition of the guidance pamphlet "The Electrical Engineer" has been written, approval for printing it secured, and plans for distribution prepared.

Considerable discussion of the subject of student papers and suggestions for changes in methods of award and nature of prizes resulted in two motions, both passed by the meeting:

1. That the committee on Student Branches consider favorably a recommendation to the committee on award of Institute prizes of a change in the grading system that would reduce the amount of emphasis placed on "importance to electrical engineering", and of an amendment of the last paragraph of the pamphlet on prize awards as it refers to undergraduate papers only.

2. That the committee on Student Branches be requested to consult with the committee on award of Institute prizes in order to make the time of awarding prizes more flexible for each District and to change the value and nature of the student prize.

Doctor C. F. Scott spoke on the importance of stimulating undergraduates to appreciate the significance of professional recognition to the electrical engineer.

Sections Committee. Meeting in New York January 23, the Sections committee voted to establish two new Sections, South Carolina and El Paso, to add unassigned territory in Maine to the Lynn Section, and to transfer Wood County, W. Va., to the Charleston Section (see "Section" items in this issue). The suggestion that the committee meet on Monday and Tuesday June 24 and 25, during the 1940 summer convention was informally approved. It was suggested that program chairmen of neighboring Sections exchange announcements of

Analysis of Registration at Recent Winter Conventions

District	1937	1938	1939	1940
New York City and foreign (3)	629	767	752	743
Middle Eastern (2)	216	292	404	412
North Eastern (1)	222	252	287	332
Great Lakes (5)	38	74	76	76
Southern (4)	21	11	16	22
Canada (10)	17	14	28	20
South West (7)	12	18	37	10
Pacific (8)	7	5	4	6
North West (9)	1	3	2	3
North Central (6)	2	2	4	2
Totals	1,165	1,438	1,610	1,626

Analysis of Registration at 1940 Winter Convention

Classification	Districts 1	2	3	4	5	6	7	8	9	10	Foreign	Totals
Members	277	360	662	16	67	2	10	5	2	18	2	1,421
Men guests	35	32	33	2	4			1	1			108
Women guests	20	20	46	4	5					2		97
Totals	332	412	741	22	76	2	10	6	3	20	2	1,626

meetings and speakers and that such announcements be sent to District vice-presidents, who should help to co-ordinate schedules for speakers.

In connection with the Section items in ELECTRICAL ENGINEERING, it was suggested that the committee request information from all Sections on such subjects as prize papers, co-ordination with other local engineering societies, sponsorship of Branch activities, membership and transfer techniques, educational courses, rotation of meeting places and formation of subsections, publicity, and local members and local membership dues.

C. R. Beardsley reported on the progress made in drafting the model law for registration of engineers and reiterated the need for a committee on legislation in every Section.

Committee on Electrochemistry and Electrometallurgy. Meeting in New York January 23, the AIEE committee on electrochemistry and electrometallurgy approved plans for a symposium on power and the electrochemical industries, to be held jointly by the AIEE Niagara Frontier Section and the Niagara Falls Section of the Electrochemical Society, at Niagara Falls, N. Y., March 14 (see page 130), and considered the possibility of holding a joint meeting with Philadelphia metallurgical groups in connection with the 1941 winter convention. The committee voted to prepare a progress report for publication in ELECTRICAL ENGINEERING, which should be completed in time to be presented at the 1941 winter convention. A subcommittee was appointed to investigate the effect of overvoltage in large units of electrochemical and electrometallurgical installations, with the aim of developing recommendations for switching devices and standards for installations. Attention was called to the report on "Electric Metal-Melting Furnaces", recently published by the Edison Electric Institute.

Committee on Education. Meeting in New York, January 23, the committee on education, after careful consideration of the returns from questionnaires to Section chairmen on the desirability and possible functions of Section education committees, expressed itself as enthusiastically favoring the establishment of Sections committees or subcommittees on (1) junior activities and education and (2) high-school vocational guidance, the latter to act jointly with Sections of other founder societies whenever possible. The committee voted to have its chairman appoint two subcommittees to assemble material and to work with Sections, one on Section activities in "Junior Sections" (like the ASCE Junior Sections), joint junior societies, co-operative educational plans with industry, and other educational programs; the other on guidance activities.

The committee also authorized the chairman to appoint a subcommittee to secure for regular monthly publication in ELECTRICAL ENGINEERING papers of an educational character. It was agreed information that membership in the subcommittees need not be limited to regularly appointed members of the committee on education. Because of the time needed for these subcommittees to make progress and the conflicting dates of the AIEE and SPEE summer conventions this year, the committee decided to prepare no program for the AIEE 1940 summer convention.

Committee on Communication. A meeting of the committee on communication was held in New York during the winter convention to discuss programs for future conventions and to arrange for a report covering a review of the activities in the field of communications since 1933. Suggestions regarding papers that might be presented in the near future were actively discussed. Two subjects of special interest were frequency modulation and velocity modulation. Arrangements have been made for a paper on frequency modulation to be presented at the summer convention and it is planned to follow with other papers, possibly at the next winter convention. The committee is also looking into the possibilities of securing for presentation at some meeting in the near future one or several papers discussing velocity modulation. This subject relates to the technique recently developed for generating and amplifying ultrahigh frequencies of the order of 2,000 megacycles.

Committees on Sound. Following the Conference on Sound of January 23 (see page 128), the technical committee on sound levels and sound-level meters met with the AIEE committee on sound on January 24, R. G. McCurdy presiding. The meeting was for the purpose of discussing proposals for changes and additions to the tentative standards for sound level meters and to consider comments received on the AIEE test code for apparatus noise measurement. Several decisions were reached regarding the tentative standards and it was agreed to submit these decisions to the entire membership of the technical committee for comment before regarding them as final. Several comments suggesting revisions in the test code were discussed and it was agreed that certain revisions would be made and the revised code would then be submitted for comment to interested parties.

CONFERENCES

The eight technical conferences held during the 1940 winter convention were on the following subjects: electric welding, network analysis and synthesis—feedback amplifiers, sound, test code for synchronous machines, transportation, increasing the use of electronic devices, standards, definitions. Brief reports of some of these conferences follow:

Electronic Devices. The technical conference on increasing the use of electronic devices sponsored by the joint committee on electronics, was attended by about 80 persons, representing in about equal number manufacturers of electronic devices, users, and educational institutions. The factor most frequently mentioned as restricting increase in the use of electronic devices is lack of specific information on tube application circuits and modes of operation of apparatus using tubes. Regarded as probably most effective for increasing the use of such devices were a few kinds of applications, each using large numbers of tubes, and the use of detailed technical publicity. (Reported by W. C. White.)

Test Code for Synchronous Machines. The technical conference on the test code for synchronous machines, held January 24, was attended by 30 or more interested individuals, including the members of the electrical machinery subcommittee on synchronous machines. The entire test code was discussed in outline, and some sections in considerable detail. The important sections on short-circuit tests, reactances, and time constants were taken up first. Hectograph copies of a proposed revision prepared by O. E. Shirley were distributed to those present. A conference paper on the "Effect of Sequential Switching on Measurement of Subtransient Reactances in Synchronous Machines" was presented by Frank von Roeschlaub. Preprint copies of this paper are still available at Institute headquarters.

A new section of the test code on the determination of the synchronizing power coefficient, P_r, used in flywheel calculations, was taken up, and prepared discussions presented by Professor Charles Kingsley and R. V. Shepherd. Specific suggestions regarding many sections of the code were next considered, and the discussion brought out points of view which will be very helpful to the subcommittee in their work of revision.

General suggestions worthy of note include one to the effect that all sections should be made as specific as reasonably possible; that where the ASA *C*-50 standards for rotating machinery cover much the same ground as the test code, the code should in general omit definitions, etc., but make specific reference to the standards; and that where useful testing information is given in the standards, it should be quoted outright in the code, so far as it covers the subject. Also, since the test code for polyphase induction machines was published in complete form in 1937 the suggestion was made that, where applicable, sections of the synchronous machine code use the same wording.

Immediately following the technical conference, the subcommittee on synchronous machines held a luncheon meeting, to organize the work of revision. It is hoped that enough progress can be made in the next few months so that the subcommittee can report the test code to the electrical machinery committee by the time of the summer convention.

Definitions. The conference, sponsored by the subcommittee on definitions of the committee on basic sciences, was held on January 25 with attendance of about 20 persons. The report of the subcommittee regarding definitions of group 05 of the final revised report of committee *C*42 was discussed. Chairman M. G. Malti pointed out the importance of framing accurate and consistent definitions of electrical terms and after reviewing the history of the activity of his subcommittee opened the meeting for discussion. It was suggested that the report be sent to a selected group of indi-

Attendance at Special Features of Recent Winter Conventions

Feature	1938	1939	1940
Total registration	1,438	1,610	1,626
Smoker	1,201	1,264	1,466
Dinner-dance	651	527	538
Inspection trips	1,012	1,167	1,700

viduals interested in the framing of definitions, for review and comment and also that a copy of the report should be sent to each engineering college for comments and suggestions. (Reported by M. G. Malti, chairman, subcommittee on definitions of the committee on basic sciences.)

Sound. The annual open conference on sound sponsored by the standards subcommittee on sound, was held January 23, with P. L. Alger presiding. About 150 were present. Progress in noise and vibration measurements was reported in one formal paper and four conference papers.

Formal paper 40-13—"Harmonic Theory of Noise in Induction Motors" by W. J. Morrill, General Electric Company

Conference paper—"New Information on Sound Levels Existing in Various Locations" by D. F. Seacord, Bell Telephone Laboratories, Inc.

Conference paper—"Sound Level Meter Standards and Tolerances" by J. M. Barstow, Bell Telephone Laboratories, Inc.

Conference paper—"Progress in Vibration Measurement. Shall a Test Code on This Subject Be Developed?" by C. D. Greentree, General Electric Company

Conference paper—"Experiences in Sound Measurements" by E. J. Abbott, Physicists Research Company

W. J. Morrill presented a theory of noise generation particularly adapted to use with small single-phase motors, with attention concentrated on the most probable sources of noise. The theory presented pointed out the various magnetic frequencies that can be expected with various combinations of rotor and stator slots. Mr. Morrill has checked his theory on a large number of motors and has found that good agreement with test results is obtained. The paper was discussed by C. G. Veinott, S. Haar, and others.

D. F. Seacord presented a report supplementing similar data presented at the 1939 conference on sound measurement, and giving the results of sound-level measurements of room noise in 2,200 locations expressed in terms of annual average levels. Values were also given representing the average differences in sound level between summer and winter conditions for various typical types of locations. The annual average sound levels and the range of variation (excluding the five per cent noisiest and the five per cent quietest locations) at three general types of location are as follows:

Type of Location	Annual Average Sound Level (Decibels)	Range Included in 90 Per Cent of Locations (Decibels)
Residence	43	33 to 52
Business	57	43 to 71
Factory	77	57 to 96

These values include the effects of variations in different types of areas ranging from rural to congested city districts. Measurements were also made at the street curb of outdoor noise which is an important contributor to room noise. Average street noise based on data including the range from rural to congested city districts is about 54 decibels at residences and 64 decibels for business locations. The corresponding values including only the congested city districts are 65 decibels for residences and 72 decibels for business locations.

J. M. Barstow discussed tolerances in the responses of sound-level meters and presented some new data on the relation between sound levels and loudness levels, demonstrating the types of noises for which the relations were obtained. It was pointed out that although the standards tolerate certain variations in response over the frequency range for which the weighting is specified, the method of calibrating does not permit the response to be consistently high or low, although within the tolerances, over the whole frequency range. Hence complex noises are more apt to be read as equal by different sound-level meters than are single frequency noises or noises in which the weighted energy lies in a narrow band of frequencies. Results of a questionnaire on proposals to reduce the tolerances below 1,000 cycles were reported. The various factors involved in reduction of tolerances, such as variations in microphone response, variation in electrical meter characteristics, and uncertainties in calibration together with their effects on the cost of manufacturing sound-level meters were discussed, and it was pointed out that as indicated by the results of the questionnaire, tolerances of the order of magnitude of those now incorporated in the standards were necessary. Small sound-level differences of each of four noises were demonstrated for the purpose of giving aural impressions of loudness differences corresponding to variations which might be expected in sound-level meter readings due to tolerances in responses. The new data presented showed the correspondence between sound levels and loudness levels for certain noises. It was recommended that more data of this type be taken, using different types of complex noises, in order that the types of noise for which the relation departs most widely from the average may be noted and examined for characteristics causing the deviation. Such information might lead to modifications in sound-level meter standards which would reduce variations in the relation between sound levels and loudness levels.

C. D. Greentree presented a proposal for the setting up of standards for vibration measurements, suggesting that standards in vibration terminology, methods of measurement, and vibration measuring instruments are needed. In vibration terminology, the word "amplitude" is often misused to indicate displacement. Mr. Greentree pointed out that amplitude can apply quantitatively to either vibration displacement, vibration velocity, or vibration acceleration. Vibration measurements can be made to determine the amplitude of either of these three quantities. In sinusoidal vibrations, if the frequency of vibration and one of the above quantities are known, the other two may be calculated. In complex vibrations, no such simple relationship exists. Hence, for the majority of vibration measurements it is necessary to choose one of these quantities. Mr. Greentree pointed out that the measurement of vibration velocity agreed better with the nuisance value of the vibration based upon its noise producing capabilities than the other two. In frequencies below the audible range, vibration velocity is also in better agreement with the nuisance effect upon the individual based upon discomfort and feeling. He strongly recommended, therefore, that the unit of vibration velocity be generally introduced as a useful method for specifying magnitudes of vibration. He also pointed out that in many cases the vibration standards for the calibration of instruments were inadequate, and concentrated effort should be directed toward the improvement of this condition.

Commenting on Mr. Greentree's talk, Mr. Scott, of the General Radio Company, agreed that vibration velocity measurements were very useful, as an indication of human discomfort with respect to noise and feeling, but pointed out that measurements of displacement and acceleration were also of importance in some applications and should certainly be included. Doctor Fletcher, of the Bell Telephone Laboratories, commented on the mathematical relationships between displacement, velocity, and acceleration for vibrations of various wave shapes. He also suggested that some fundamental work must be done to assure correct definitions and calibration methods in this new field of vibration measurements, just as were necessary at the start of the work on sound standards; so that the AIEE committee should work closely with the ASA group rather than going ahead independently. Mr. Parkinson, of the Johns-Manville Company, was highly in favor of setting up vibration tandards and felt that vibration velocity units should be used in the audible range and also outside the audible range, although others may also be important there.

Mr. Alger then asked for an expression of opinion on the desirability of initiating work on a vibration test code in co-operation with the American Standards Association. It was agreed that this should be done.

V. L. Chrisler, of the Bureau of Standards, commented on his experiences in noise measurements during the past year on fans, stating that differences of 2 to 3 decibels were encountered between measuring instruments caused mainly by differences in over-all acoustic response above 2,000 or 3,000 cycles per second.

Ernest J. Abbott, Physicists Research Company, indicated that altogether too much attention is given to the very academic point of the relation of loudness to sound pressure. We should admit at the outset that sound levels are not loudness, but what of it? The sound levels are none the less useful. From a practical point of view, we can forget about loudness. It is a highly speculative and elusive thing at best. The loudness of ordinary sounds cannot be measured with any known instruments but this is no especial drawback. In fact, it is doubtful if we would find much use for loudness readings even if we could obtain

Future AIEE Meetings

Summer Convention
Swampscott, Mass., June 24–28, 1940

Pacific Coast Convention
Los Angeles, Calif., August 26–30, 1940

Winter Convention
Philadelphia, Pa., January 27–31, 1941

them. Let's quit trying to justify sound level measurements on the basis of loudness, and let us instead recognize the value of sound level on its own account. The sound pressure of a sound is a definite physical quantity which can be measured and which practical experience has proved to be very useful in a wide variety of applications. No excuses are needed to justify the use of sound level readings.

National • • • •

Board of Directors Meets During Winter Convention

At its regular meeting at Institute headquarters, January 23, 1940, the AIEE board of directors approved the following dates and places for meetings:

Annual meeting, 1940, Swampscott, Mass., Monday, June 24. Pacific Coast Convention, 1940, Ambassador Hotel, Los Angeles, Calif., August 26–30 inclusive (selected by convention committee)

Schedule of 1941 conventions and district meetings:

Winter convention, Philadelphia, Pa., January 27–31

Summer convention, Toronto, Can., June 16–20

North Eastern District meeting, Rochester, N. Y., May

Great Lakes District meeting, Fort Wayne. Ind., April

South West District meeting, St. Louis, Mo., date to be determined, not too near other meetings

Dates for the 1941 summer convention, which are a week earlier than usual, were selected to avoid conflicting with the annual meeting of the Society for the Promotion of Engineering Education, to be held at Ann Arbor, Mich., the following week.

Recommendations of the Sections committee for formation of two new Sections, South Carolina and El Paso, and addition of unassigned territory in Maine to the Lynn Section, were approved.

The board approved for printing a revision of AIEE Standard No. 4, "Measurement of Test Voltages in Dielectric Tests", and authorized an appropriation to reprint "The Electrical Engineer", pamphlet to be sold at headquarters for five cents and by mail for ten cents per copy.

Appointments approved by the board were:

Charles LeGeyt Fortescue Fellowship committee

Name	Term Expires
C. A. Powel, chairman	July 31, 1940
D. C. Prince	July 31, 1940
W. F. Davidson	July 31, 1941
W. I. Slichter	July 31, 1941
O. E. Buckley	July 31, 1942
E. S. Lee	July 31, 1942

Appointments by standards committee:

C. H. Sanderson, chairman, sectional committee on definitions of electrical terms (succeeding A. E. Kennelly, deceased)

H. M. Turner, AIEE representative, sectional committee on radio, C16 (succeeding C. H. Sharp, deceased)

Institute representatives, council of American Association for the Advancement of Science:

J. W. Barker   Vannevar Bush

Since the number of papers presented for District prizes is sometimes very small, the pamphlet "National and District Prizes" was amended, upon recommendation of the committee for the award of Institute prizes, to permit consideration for District prizes of papers accumulated over a number of years. The amended paragraph (page 6, January 1937 edition) reads:

"Only papers presented subsequent to the period covered by the last previous award in the class and prior to the end of the last calendar year shall be considered for the prize for best paper and for initial paper. Only papers presented subsequent to the period covered by the last previous award in the class and prior to the end of the last academic (college) year, July 1 to June 30 inclusive, shall be considered for the prize for Branch paper and for graduate student paper."

The board also approved a recommendation from the committee on planning and coordination for the engagement of Science Service to prepare and publicize several AIEE technical-committee reports. The project, which is an experiment for one year only, authorizes reports of progress of the electrical art in the various fields chosen to be written by Science Service for publication in TRANSACTIONS from material supplied by the committees. In addition, popular versions of the reports may be published in *Science News Letter*, supplied to newspapers and other publications by Science Service, and, if of sufficiently broad interest, broadcast by radio.

As a result of a recommendation from Vice-President A. H. Lovell, chairman of the committee on economic status of the engineer, the president was authorized to appoint a committee to investigate conditions under which young engineers are working and to report its findings and recommendations to the board.

The appropriation for American Engineering Council for the year ending September 30, 1940, was increased from $6,000 to $8,333.33.

Other actions included:

Approval of minutes of board of directors meeting, October 27, 1939 and of executive committee meeting, December 11, 1939.

Confirmation of executive committee action, December 27, 1939, on transfer, admission, and Student enrollment as follows:
3 applicants transferred to grade of Fellow; 7 transferred and 4 elected to grade of Member; 47 elected to grade of Associate; 413 Students enrolled.

Approval of reports of board of examiners meetings, December 21, 1939, and January 18, 1940; action on recommendations as follows: 6 applicants transferred to grade of Fellow; 9 transferred and 14 elected to grade of Member; 89 elected to grade of Associate; 96 Students enrolled.

Approval of finance committee reports: expenditures, December, $24,337.33; January, $26,408.86.

Those present were:

President—F. Malcolm Farmer, New York, N. Y.

Past Presidents—W. H. Harrison, John C. Parker, New York, N. Y.

Vice-Presidents—T. F. Barton, New York, N. Y.; F. C. Bolton, College Station, Tex.; Chester L. Dawes, Cambridge, Mass.; L. R. Gamble, Spokane, Wash.; H. W. Hitchcock, Los Angeles, Calif.; A. H. Lovell, Ann Arbor, Mich.; Fred R. Maxwell, Jr., University, Ala.; C. T. Sinclair, Pittsburgh, Pa.; J. M. Thomson, Toronto, Can.; A. L. Turner, Omaha, Nebr.

Directors—C. R. Beardsley, H. S. Osborne, New York, N. Y.; Mark Eldredge, Memphis, Tenn.; R. E. Hellmund, C. A. Powel, East Pittsburgh, Pa.; F. H. Lane, L. R. Mapes, Chicago, Ill.; K. B. McEachron, Pittsfield, Mass.; F. J. Meyer, Oklahoma City, Okla.; D. C. Prince, Philadelphia, Pa.; R. W. Sorensen, Pasadena, Calif.

National Treasurer—W. I. Slichter, New York, N. Y.

National Secretary—H. H. Henline, New York, N. Y.

Official Candidates Announced by Nominating Committee

A complete official ticket of candidates for the Institute offices that will become vacant August 1, 1940, was selected by the national nominating committee at its meeting held at Institute headquarters, New York, N. Y., January 24, 1940. This committee in accordance with the constitution and bylaws, consists of 15 members, 1 selected by the executive committee of each of the 10 geographical Districts, and 5 selected by the board of directors from its own membership. All of the members of the committee were present, as follows:

C. R. Beardsley, New York, N. Y.; C. L. Dawes, Cambridge, Mass.; Mark Eldredge, Memphis, Tenn.; J. M. Flanigen, Atlanta, Ga.; Fred Garrison, Los Angeles, Calif.; W. B. Hall, Kingston, R. I.; A. S. Langsdorf, St. Louis, Mo.; T. G. LeClair, Chicago, Ill.; A. H. Lovell, Ann Arbor, Mich.; C. A. Powel, East Pittsburgh, Pa.; I. M. Stein, Philadelphia, Pa.; George Sutherland, New York, N. Y.; J. M. Thomson, Toronto, Ont.; A. L. Turner, Omaha, Neb.; H. L. Vincent, Spokane, Wash.; and H. H. Henline, secretary of the committee.

Following is the list of official candidates selected by the committee:

FOR PRESIDENT

R. W. Sorensen, professor and head of the department of electrical engineering, California Institute of Technology, Pasadena, Calif.

FOR VICE-PRESIDENTS

Everett S. Lee, engineer, general engineering laboratory, General Electric Company, Schenectady, N. Y. (North Eastern District, number 1)

J. W. Barker, dean of engineering, Columbia University, New York, N. Y. (New York City District, number 3)

K. L. Hansen, consulting engineer, Harnischfeger Corporation, Milwaukee, Wis. (Great Lakes District, number 5)

J. L. Hamilton, assistant vice-president, Century Electric Company, St. Louis, Mo. (South West District, number 7)

A. LeRoy Taylor, dean, school of mines and engineering, University of Utah, Salt Lake City, Utah. (North West District, number 9)

FOR DIRECTORS

T. F. Barton, assistant district manager and district engineer, General Electric Company, New York, N. Y.

M. S. Coover, professor and head of electrical-engineering department, Iowa State College, Ames, Iowa

R. G. Warner, electrical engineer, United Illuminating Company, New Haven, Conn.

FOR NATIONAL TREASURER

W. I. Slichter, professor of electrical engineering and head of department, Columbia University, New York, N. Y.

The constitution and bylaws of the Institute provide that the nominations made by the committee shall be published in the March issue of ELECTRICAL ENGINEERING. Provision is made for independent nominations as indicated in the following excerpts from the constitution and bylaws:

CONSTITUTION

Sec. 31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the national secretary when and as provided in the bylaws; such petitions for the nomination of vice-presidents shall be signed only by members within the District concerned.

BYLAWS

Sec. 23. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with Article VI, Section 31 (Constitution), must be received by the secretary of the national nominating committee not later than March 25th

of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the national nominating committee in accordance with Article VI of the Constitution and sent by the national secretary to all qualified voters during the first week in April of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

(*Signed*) National Nominating Committee
by H. H. Henline, *Secretary*

BIOGRAPHICAL SKETCHES OF NOMINEES

In order that those not personally acquainted with the nominees may know something of them and their qualifications for the Institute offices for which they have been nominated, brief biographical sketches are given in the "Personals" columns of this ssue.

1941 Winter Convention to Be Held in Philadelphia

On recommendation of the Philadelphia Section, approved by the board of directors, the 1941 AIEE winter convention will be held in Philadelphia, Pa., January 27–31, 1941. This will be the first time the winter convention has been held outside New York since 1924, when it was also held in Philadelphia. N. E. Funk (A'07, F'34) vice-president in charge of engineering, Philadelphia Electric Company, has been appointed chairman of the general convention committee, now being formed. He was also chairman of the general convention committee for the annual meeting of the American Society of Mechanical Engineers held in Philadelphia December 4–8, 1939.

Section • • • •

El Paso, South Carolina Sections Authorized

Formation of two new Sections of the Institute, bringing the total to 70, was authorized by the board of directors at its meeting, January 23, 1940. The South Carolina Section, has that entire state as its territory. A formal organization meeting was held at Columbia, S. C., March 1. The Section plans to hold two meetings a year until it becomes well established, when the number will be increased. The El Paso Section includes El Paso, Hudspeth, Culberson, Presidio, Jeff Davis, Brewster, Terrell, Pecos, Reeves, Loving, Crane, Winkler, Ward, Ector, Midland, Glasscock, Sterling, Coke, Green, Irion, Reagan, and Upton counties in Texas, and the entire state of New Mexico.

Joint Symposium at Niagara

The Niagara Frontier Section of the AIEE and the Niagara Falls Section of the Electrochemical Society are holding a joint symposium on "Power and the Electrochemical Industry," at Niagara Falls, N. Y., March 14, 1940. Speakers are L. H. Fletemeyer, E. I. du Pont de Nemours and Company, Inc.; C. N. Richardson, Mathieson Alkali Works; R. G. Mansfield, Union Carbide Company, all of Niagara Falls; C. C. Levy, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.; William Kelly, president, Buffalo Niagara and Eastern Power Corporation, Buffalo, N. Y.; N. R. Stansel, General Electric Company, Schenectady, N. Y. Sessions will be held in the afternoon and evening, with a dinner at which F. A. Lidbury, president, Oldsbury Electrochemical Company, Niagara Falls, will be toastmaster, and C. L. Dawes, vice-president, North Eastern District, and Colin G. Fink, secretary, Electrochemical Society, will speak.

Prize Paper Contest for Maryland Section Students

All Enrolled Students in the Maryland Section are eligible to submit papers on electrical or closely allied subjects to the Section's first prize paper contest for Students. The first prize is an engraved sterling silver goblet, and the second prize an engraved sterling silver key chain. The contest closes March 15, 1940, and the winning papers will be presented at a special meeting of the Section and Student Branches April 29. Members of the Section are being urged to encourage Students to submit papers.

The following items are contributed by C. A. Faust, Mansfield, Ohio, for the Sections committee

Charleston Section Acquires Wood County

Upon the request of the Charleston Section and with the approval of the Columbus Section, Wood County, W. Va., has been transferred from Columbus to Charleston's territory. Parkersburg, the principal city in the county, is the residence of four Institute members, according to the 1939 yearbook.

Entire State of Maine Now in Lynn Section

Nine previously unassigned counties in Maine—Franklin, Somerset, Aroostook, Piscataquis, Penobscot, Washington, Hancock, Knox, and Waldo—have been added to the Lynn Section's territory, making the entire state of Maine a part of this Section. Eleven members of the Institute resided in this territory when the 1939 yearbook was compiled.

Seattle Has Prize Papers, Technical Committees

Joint prizewinners for papers presented at the last annual "members' papers meeting" of the Seattle Section were H. M. Steen, Seattle Cedar Lumber Manufacturing Company, and C. M. Wolfe, instructor in electrical engineering, University of Washington. Mr. Steen's paper was "A Three-Element Cathode-Ray Oscillograph"; and Mr. Wolfe's "The Electrical Dehydration of Crude-Oil Emulsions." The meeting was held December 19, 1939, the date having been changed from February to conform to the changed date for consideration of papers for District and National prizes.

For 14 years the Seattle Section has held a yearly meeting for presentation of papers by its members. It was called the "prize papers meeting" until last year, when the name was changed to avoid emphasis on the idea of a contest. When three or more papers are presented, a first prize of $20 and a second prize of $10 are awarded. Rules for judging papers are the same as for AIEE District and National awards, except that entries need not be first papers. Papers are discussed by the Section while the judges are deciding upon the winners.

Seattle holds a similar meeting each April for presentation of papers by Enrolled Students, awarding the winner his first year's dues as Associate in the AIEE.

Technical committees on electronics and power have been reinstated by the Seattle Section after a year's lapse. In 1936–37 the Section had four such study groups, and the two mentioned were continued in 1937–38. When no group meetings were held last year, the number of inquiries caused the Section to resume the activity.

Policy on Local Members Differs in Lynn and Springfield

By planning its programs well in advance, scheduling several interesting meetings for a season, and conducting an intensive membership drive, the Lynn Section secured 665 local members in 1938–39 and 830 in the preceding year. The annual fee of $1.50 per person provides considerable additional revenue for the Section. Local membership is open to all interested men and women. Payment of the annual fee entitles a local member to participate in all activities and to bring one woman guest or one child to each event. Before commencing the membership drive, a complete program of the Section activities is compiled, and a membership committee representing manufacturing, utility, and other companies is appointed. Advertising is carried in local newspapers and posters are distributed. The committee canvasses all prospects. Each local member receives a copy of the season's program and the Section's annual report. Membership tickets are also sold at the door at various lectures and activities.

To be eligible for local membership in the Springfield Section, a candidate must be at least 18 years of age and interested in the objects of the Section. He must be recommended for membership by some one connected with the Section and give three personal references. Finally, he must be approved by the membership committee and pay the annual dues of $2, or $1 after January 1. A local member receives notices of meetings, may attend all meetings, and may serve on committees, but cannot vote, hold office, or be chairman of a committee. The Section has had local members for over ten years.

Standards . . .

U. S. National Committee of I E C. On January 4, 1940, Doctor E. C. Crittenden, assistant director of the International Bureau of Standards accepted the appointment as president of the United States National Committee of the International Electrotechnical Commission, to succeed Doctor Clayton H. Sharp, who had served in that position for 16 years, and who has now been elected honorary president.

Industrial Lighting. I. A. Yost of the Westinghouse Electric and Manufacturing Company has been appointed representative of the AIEE on the Sectional Committee on Industrial Lighting, *A*-11.

Mining Standardization Correlating Committee. The Institute has just reappointed for a period of two years L. C. Ilsley of the Bureau of Mines experiment station as its representative to serve for a period of two years on the Mining Standardization Correlating Committee.

Evaluation of Insulation in Service. C. A. Powel, chairman of standards co-ordinating committee 3, "Insulation Testing and Co-ordination", has formed a subcommittee under Doctor C. F. Hill of Westinghouse Electric and Manufacturing Company to review standard insulation tests and make a study of methods of evaluating insulation in service.

New Co-ordinating Committees. At the January 12 meeting of the standards committee two new co-ordinating committees were authorized: co-ordinating committee 5 on basic theories and units, and co-ordinating committee 6 on interference, sound, and noise problems. The latter will be under the chairmanship of R. G. McCurdy, Bell Telephone Laboratories, and will supersede the present subcommittee on sound. The other members of the committee will be P. L. Alger, W. F. Davidson, R. D. Evans, and Gordon Thompson.

Radio. Professor H. M. Turner of Yale will succeed Doctor C. H. Sharp as an Institute representative on the Sectional Committee on Radio, *C*16. The other members of the AIEE delegation are W. C. White, General Electric Company, and W. Wilson, Bell Telephone Laboratories.

Classification of Representatives. For years it has been the understanding and policy of the standards committee that Institute representatives serving on standardizing committees act in accordance with their views as engineers and not from the viewpoint of company affiliation. In ASA practice it has become the custom, unless they are otherwise instructed, to classify organization representatives according to payroll affiliation. The standards committee therefore at its January 12 meeting directed that in future all AIEE delegates be classified as "General Interests". Delegates are to be advised of this action and urged to seek the advice of the standards committee where partisan interests conflict.

Personal . . .

R. W. Sorensen Nominated for Institute President

Royal Wasson Sorensen (A'07, M'13, F'19), professor and head of the department of electrical engineering, California Institute of Technology, Pasadena, has been nominated for the presidency of the AIEE for the 1940–41 term. Born at Alta Vista, Kans., April 25, 1882, he received the degrees of bachelor of science in electrical engineering in 1905 and electrical engineer in 1928, and the honorary degree of doctor of science in 1938, from the University of Colorado. His professional career began in 1905, when he entered the test department of General Electric Company at Schenectady, N. Y. The following year he was made foreman of the transformer test department and later entered the commercial section of the transformer engineering department. In 1908 he was transferred to the Pittsfield, Mass., transformer works of the company. He was made associate professor of electrical engineering, in charge of the department, at Throop Polytechnic Institute (now California Institute of Technology) in 1910, and promoted to full professor the next year. He has held that position ever since. He has also been engaged in consulting practice in various fields since 1913, and since 1931 has been a member of the board of consulting engineers for the Metropolitan Water District of Southern California. His association with the Institute began as an Enrolled Student in 1904. He has been secretary and chairman of the Los Angeles Section (1919–21), Student Branch counselor at California Institute of Technology (1930–33, 1935–36), secretary and chairman of the District 8 committee on Student activities (1926–27). He is chairman of the committee on Student Branches (1938 to date, member 1927–28, 1936 to date) and is serving or has served on the following other national committees: Edison Medal (1938 to date), membership (1939 to date), planning and co-ordination (1939 to date), education (1924–28, 1934–37, 1939 to date), economic status of the engineer (1936 to date, chairman 1936–38), research (1923–24, 1927–30), instruments and measurements (1927–30), Lamme Medal (1933–36), special committee on Institute activities (1936–37). He was vice-president representing District 8, 1933–35, and is now serving as a director. His paper, "The Economic Status of the Engineer", was awarded the 1938 AIEE national prize for best paper in public relations and education. In addition to his Institute activities he is now serving as a vice-president of the Society for the Promotion of Engineering Education, and is also a member of the Engineers' Council for Professional Development and of Tau Beta Pi and Sigma Xi.

Vice-Presidential Nominees Are Lee, Barker, Hansen, Hamilton, and Taylor

Everett Samuel Lee (A'20, M'28, F'30) engineer in charge of general engineering laboratory, General Electric Company, Schenectady, N. Y., has been nominated to serve the Institute as vice-president, representing the North Eastern District (number 1). He was born at Chicago, Ill., November 19, 1891, and received the degrees of bachelor of science in electrical engineering from the University of Illinois in 1913 and of master of science in electrical engineering from Union College in 1915. From 1913 to 1916 he was an instructor in electrical engineering at Union College and a laboratory assistant at General Electric Company, Schenectady, N. Y. He was with the Locomotive Stoker Company, Chicago, 1916–17, and after a year in charge of machine gunnery at the United States Army School of Military Aeronautics at Urbana, Ill., returned to General Electric in 1918. He has been with the company continuously since that time, becoming assistant engineer of the general engineering laboratory in 1928 and assuming his present position in 1931. He has been a director of the Institute (1933–37) and chairman of the Schenectady Section (1928–29), and has served on the following national committees: executive (1933–37), headquarters (1936–37), Sections (1929–34), meetings and papers (1927–30; now technical program committee), membership (1933–38, chairman 1933–36), finance (1933–37, chairman 1936–37), transfers (1934–36, 1937–39, chairman 1937–39). He represented the Institute on the division of engineering and industrial research of the National Research Council (1936–39). He is at present chairman of the committee on constitution and bylaws (member 1937 to date) and a member of the committees on instruments and measurements (1927 to date), research (1934–36, 1939 to date), Edison Medal (1934–36, 1937 to date), planning and co-ordination (formerly co-ordination of Institute activities, of

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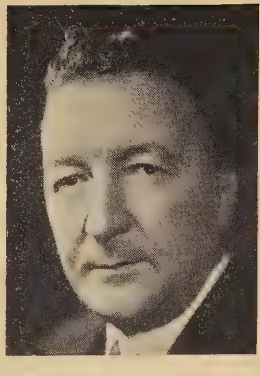
R. W. SORENSEN

E. S. LEE

J. W. BARKER

J. L. HAMILTON



K. L. HANSEN

A. L. TAYLOR

T. F. BARTON

M. S. COOVER

which he was a member 1930–33, 1936–37), and now and in past years has been active on special committees, and in committee work for other technical societies. He is a member of Tau Beta Pi, Sigma Xi, and Eta Kappa Nu.

Joseph Warren Barker (M'26, F'30) dean of engineering, Columbia University, New York, N. Y., has been nominated to serve the Institute as vice-president representing the New York City District (number 3). He was born June 17, 1891, at Lawrence, Mass., and received the degrees of bachelor of science (1916) and master of science (1925) in electrical engineering from Massachusetts Institute of Technology. He served in the Coast Artillery Corps of the United States Army as artillery engineer and adjutant from 1916 to 1925, part of that time as officer in charge of civil affairs of the American forces in Germany. He was appointed associate professor of electrical engineering at Massachusetts Institute of Technology, Cambridge, in 1925, and in 1929 became professor and head of the department of electrical engineering at Lehigh University, Bethlehem, Pa. Since 1930 he has been professor and dean of the faculty of engineering at Columbia University. He is at present chairman of the Institute's technical program committee (member since 1932) and of the committee on award of Institute prizes (member since 1937) and a member of the committees on publication (1934 to date), Edison Medal (1938 to date), education (1930 to date, chairman 1937–39), and planning and co-ordination. He has also served on the committee on production and application of light (1929–39, chairman 1933–35). He represents the Institute on the Iwadare Foundation (1936 to date) and on the United States national committee of the International Electrotechnical Commission. He is a past president of the Illuminating Engineering Society and a member of The American Society of Mechanical Engineers, American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, Society for the Promotion of Engineering Education, Tau Beta Pi, and Sigma Xi, and has been active in the division of engineering and industrial research, National Research Council.

Klaus Lobeck Hansen (A'17, F'34) consulting engineer, Harnischfeger Corporation, Milwaukee, Wis., has been nominated to serve the Institute as vice-president representing the Great Lakes District (number 5). He was born in Sandefjord, Norway, September 14, 1882, and came to the United States in 1901. He was employed by the National Stamping Works, and the Western Electric Company, both at Chicago, Ill., before entering the University of Illinois where he studied electrical engineering 1903–05. After several months with the Chicago Edison Company, he was employed by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., in 1906 and continued with the company until 1919, his last position being designing engineer on d-c apparatus. In 1919 he went with the Mechanical Appliance Company (later the Louis Allis Company), Milwaukee, as designing engineer later becoming chief engineer. He left the company in 1921 to engage in consulting and development work on his own patents. He invented the Hansen arc welder, and in its manufacture and sale was associated with the Northwestern Manufacturing Company, Milwaukee, from 1924 to 1932, when it was taken over by the Harnischfeger Corporation. He holds patents on various arc-welding processes and joint patents on induction motors, and has published a number of technical papers, chiefly concerned with welding. He has been a member of the Institute's electric welding committee 1930 to date (chairman 1932–34), was chairman of the Milwaukee Section 1933–34, and chairman of the 1937 AIEE summer convention committee. He is also a member of the American Welding Society, at present serving as vice-president representing its Middle Western Section.

James Lemmon Hamilton (M'15, F'21) assistant vice-president, Century Electric Company, St. Louis, Mo., has been nominated to serve the Institute as vice-president representing the South West District (number 7). He was born September 24, 1883, at Morrisville, Mo., and received the degree of bachelor of science in electrical engineering from the University of Missouri in 1904. After graduation he went with the Emerson Electrical Manufacturing Company, St. Louis, on electrical and mechanical designing, becoming manager of design and development in 1913. In 1915 he became chief engineer of the Century Electric Company, St. Louis, in charge of all engineering work. He was made a director of the company in 1920, and in 1934 became assistant vice-president, with executive responsibility for engineering, research, standards, and manufacturing. He is a member of the American Society for Testing Materials and the National Electrical Manufacturers Association, and is a member of the Institute's committee on electrical machinery (1926–27, 1932 to date, chairman 1936–38).

Albert LeRoy Taylor (M'28) dean of the school of mines and engineering and head of the electrical-engineering department, University of Utah, Salt Lake City, has been nominated to serve the Institute as vice-president representing the North West District (number 9). He was born May 14, 1887, at Logan, Utah, and received the degree of bachelor of science in electrical engineering from the University of Utah in 1907 and that of master of science from the University of Michigan in 1918, and has also done graduate work at Stanford University. He was employed by General Electric Company at Schenectady, N. Y., 1910–11, in the test department and standardizing laboratory. He became an instructor in electrical engineering at the University of Utah in 1911, and except for two years (1912–14) as manager of a contracting firm, and various absences for graduate study, has remained with the University ever since. He was instructor in electrical engineering 1914–18, assistant professor of mechanical engineering, 1918–22, associate professor of mechanical engineering 1922–28, and was made professor and head of the department of electrical engineering in 1929, and dean of the school of mines and engineering in 1939. He has also carried on consulting engineering practice and is the author of a textbook and technical papers. He has been secretary (1931–32) and chairman (1932–33) of the Utah Section and Student Branch counselor (1935–39) and District chairman of Branch counselors (1939). He is also a member of the American Society of Mechanical Engineers, Society for Promotion of Engineering Education, Tau Beta Pi, and Sigma Xi.

Barton, Coover, and Warner Nominated for Institute Directorships

Theophilus Fisk Barton (A'12, M'18, F'30) assistant manager of the New York district, General Electric Company, New York, N. Y., has been nominated to serve as a member of the AIEE board of directors. He

was born December 25, 1885, at Orangeburg, S. C., and studied electrical and mechanical engineering at Clemson Agricultural College, where he received the degree of bachelor of science. In 1906 he entered the testing department of General Electric Company, at Schenectady, N. Y., and in 1909 was transferred to the d-c engineering department. He served in the engineering department of the company's New York office from 1911 to 1917, when he returned to Schenectady as a section head in the central-station-engineering department. He became district engineer of the New York district in 1927, and in 1939 was appointed to his present position. Mr. Barton has twice won Charles A. Coffin Foundation awards for contributions to the electrical industry. He is at present AIEE vice-president representing District 3, and was chairman of the New York Section (1932–33) and chairman of the 1939 winter convention committee. He is a member of the committees on economic status of the engineer (1935 to date), legislation affecting the engineering profession (1931 to date, chairman 1935–37), and industrial power applications, and of the executive and finance committees, and has also served on the membership committee (1917–18), transfers committee (1935–36), board of examiners (1934–37), and on several special committees.

Mervin S. Coover (A'16, M'32) professor and head of the department of electrical engineering, Iowa State College, Ames, has been nominated to serve the Institute as a member of the board of directors. He was born December 9, 1890, at Shippensburg, Pa., and received the degree of electrical engineer at Rensselaer Polytechnic Institute in 1914. The following year he was a student engineer with the New York Central Railroad Company, New York, N. Y. He was engaged in electrical construction work for the Montana Power Company, the Hutchinson (Kans.) Light and Power Company, and the Wilson Grinding Machine Company, Wichita, Kans., until 1918 when he entered the United States Army. In 1919 he became an instructor in electrical engineering at the University of Colorado, Boulder, becoming assistant professor, 1920, associate professor, 1922, and professor, 1930. During the summers he engaged in consultation work for various organizations. He was appointed to his present position at Iowa State College in 1935. He has served the Institute as secretary of the North Central District (1929–33), was a member of the automatic stations committee (1927–29), and is now a member of the committees on Sections (1937 to date), education (1937 to date), and research (1937 to date). He is a director of the Iowa Engineering Society and a member of the Society for Promotion of Engineering Education and Eta Kappa Nu.

Russell Gillette Warner (A'19, M'20) engineer, United Illuminating Company, New Haven, Conn., has been nominated to serve as a member of the Institute's board of directors. Born at New Haven, November 18, 1892, he received the degrees of bachelor of philosophy (1914) and electrical engineer (1920) from Yale University. He was with the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., 1914–16, in the student course and later as switchboard engineer. He became an instructor in the department of electrical engineering at Yale University, New Haven, in 1916, and continued in the department as instructor and assistant professor until 1939, when he was appointed engineer in charge of special reorganization work by the United Illuminating Company, New Haven. He was also electrical engineer for the Connecticut Public Utilities Commission 1930–39 and has been consulting engineer for various companies. He has been secretary (1926–31) and chairman (1931–32) of the AIEE Connecticut Section, served on the Institute committees on education (1924–25), electrical machinery (1931–33), and standards (1937–39). He has been secretary of the Connecticut Technical Council since its formation in 1934, and is a member of the Society for Promotion of Engineering Education, Tau Beta Pi, and Sigma Xi.

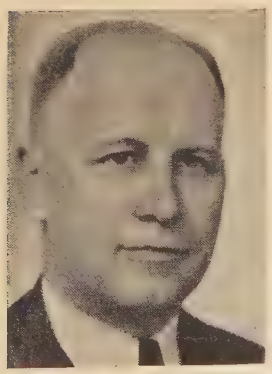
W. I. Slichter Renominated as Institute Treasurer

Walter Irvine Slichter (A'00, M'03, F'12) professor and head of the department of electrical engineering at Columbia University, New York, N. Y., has been renominated to serve as treasurer of the Institute. He has held the position of national treasurer since 1930, and has also served the Institute as a manager (1918–22), vice-president (1922–24), and member of many committees. He is at present a member of five committees and one special committee, and Institute representative on four joint bodies. A biographical sketch of Professor Slichter appeared in the March 1938 issue, page 136.

N. W. Storer to Receive Lamme Medal

Norman Wilson Storer (A'95, F'13) retired consulting railway engineer of the Westinghouse Electric and Manufacturing Company, has been awarded the AIEE Lamme Medal for 1939 "for meritorious achievement in the development of apparatus and machinery for electrical transportation." He was born at Orangeville, Ohio, January 11, 1868, and graduated from Ohio State University with the degree of mechanical engineer in electrical engineering in 1891. In September of that year he entered the employ of the Westinghouse company at East Pittsburgh, Pa., in which he continued without interruption until his retirement in 1936. In 1893 he became assistant to B. G. Lamme (A'03, M'03, Edison Medallist) on the design of d-c machines, especially railway motors. During this period he developed a method of rating railway motors which was later adopted as standard by both the AIEE standards committee and the International Electrotechnical Commission. In 1904 the company's engineering department was reorganized and Mr. Storer was made engineer of the railway division, devoting his entire time to electric transportation. He made notable contributions to the development of both single-phase and high-voltage d-c railway electrificatons, and later had charge of developing electrical equipment for oil electric cars and locomotives. In 1926 he was appointed consulting railway engineer. He has served the Institute as manager (1911–13) and twice as vice-president (1914–16, 1921–23); he has also been Institute representative on the United States national committee of the International Electrotechnical Commission, for which he was advisor on railway motors, and has been active on technical committees, especially the standards and transportation committees. He is the author of many technical papers. In 1933 he was awarded the Lamme Medal of Ohio State University.

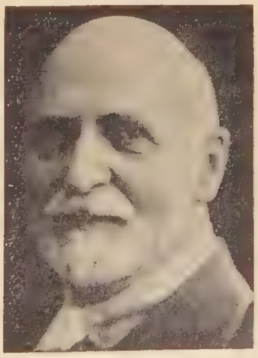
Alex Dow (A'93, F'13, HM'37) has retired as president of the Detroit Edison Company, Detroit, Mich., to become chairman of the



R. G. WARNER

A. C. MARSHALL

N. W. STORER



ALEX DOW

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D. M. SIMMONS

company's executive committee. He has been president since 1913. He was born in Glasgow, Scotland, April 12, 1862. Although he received no formal technical education, he holds the honorary degrees of master of engineering (1911) and doctor of engineering (1924) from the University of Michigan, and doctor of science (1935) from the University of Detroit. He came to the United States in 1882, becoming a naturalized citizen in 1895. From 1882 to 1888 he was employed by the Baltimore and Ohio Railroad and the Baltimore and Ohio Telegraph Company, and in 1888 was employed as installation electrician at Chicago, Ill., by the Brush Electric Company, becoming district engineer in the Chicago office in 1889. He took charge of the design and construction of the first public lighting plant of the city of Detroit in 1893, and in 1896 became vice-president and general manager of the Edison Electric Illuminating Company of Detroit, continuing as vice-president of the successor company, the Detroit Edison Company, until 1913, when he became its president. He was engineer member of the Detroit Board of Water Commissioners 1916–21 and 1925–27. He was awarded the AIEE Edison Medal for 1936 for "outstanding leadership in the development of the central-station industry and its service to the public." He is also a member and honorary member of both the American Society of Civil Engineers and American Society of Mechanical Engineers and past president of the latter, charter member and past president of the Detroit Engineering Society, member of the Institution of Electrical Engineers of Great Britain, and honorary life member of the Institution of Mechanical Engineers.

A. C. Marshall (A'14, F'29) has been appointed president of the Detroit Edison Company, Detroit, Mich. He was formerly vice-president and general manager. Born September 12, 1872 at Middletown, Ohio, he received the degree of bachelor of science in electrical engineering from the University of Michigan in 1893. After a short period as assistant electrical inspector for the Michigan Inspection Bureau, Detroit, he was employed as field engineer and electrician by the Public Lighting Commission of the City of Detroit in 1894. In 1899 he became chief engineer of the Rapid Railway System, Detroit. He was employed by the Detroit Edison Company on construction in 1904–05, but left the company to become general manager of the Port Huron, Mich., Light and Power Company. In 1911 he became assistant to the president, Eastern Michigan Edison Company, a subsidiary of Detroit Edison, and in 1912 was appointed vice-president of the latter company. He had been vice-president and general manager of the company since 1921.

D. M. Simmons (A'22, F'28) chief engineer, General Cable Corporation, New York, N. Y., has been made a director of the company. Born in New York, July 29, 1889, he received the degrees of bachelor of arts (1911) and electrical engineer (1913) and the honorary degree of doctor of engineering (1939) from Princeton University. He was employed by the Standard Underground Cable Company in research and engineering work at Pittsburgh, Pa., from 1913 until 1927, when that company joined with others to form the General Cable Corporation. He was made director of high-voltage engineering in the latter company in 1928 and chief consulting engineer in 1930. He holds a number of patents in the United States and other countries and is the author of many technical articles. He is past president of the Insulated Power Cable Engineers Association, and has served the AIEE as chairman of the Pittsburgh Section and member of several committees.

S. E. Schultz (A'25) has been appointed acting chief engineer for the Bonneville project, Portland, Ore. For some months he had been engaged in research and investigation work on the staff on a consulting basis, and before that time was electrical engineer for the Port of New York Authority, New York, N. Y. A native (1899) of Oil City, Pa., he graduated in electrical engineering at Drexel Institute. He was employed as meter tester and later meter superintendent by the Citizens Light and Power Company, Oil City, 1918–20, and as meter tester by the Philadelphia Electric Company, 1920–23. After some months as traffic engineer for the Bell Telephone Company of Pennsylvania, he became distribution engineer for Consumers Power Company, Oil City, in 1924. He was later electrical engineer for Stevens and Wood, and engineer for the Quad Engineering Company, both of New York, N. Y., before becoming assistant electrical engineer for the Port of New York Authority in 1935. He later became electrical engineer. Other recent appointments to the Bonneville staff include **D. L. Campbell** (A'38), formerly superintendent of high lines, City of Seattle (Wash.) Lighting Department, as senior transmission engineer; **R. F. Stevens** (A'36) former electrical engineer, Bonneville project, as senior design engineer; **O. A. DeMuth** (A'23, M'30) formerly associate engineer of the project, as senior system engineer; and **C. C. Long** (A'14, M'20), formerly senior electrical engineer, City of Los Angeles, Calif., Metropolitan Water District, as operations engineer.

Frank Conrad (A'02, F'37) assistant chief engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has been awarded the gold medal of the American Institute of the City of New York. The award was made "for his pioneering work in short-wave radio and frequency modulation and for his guiding genius developing the world's first radio broadcasting system". Doctor Conrad was awarded the Edison Medal for 1930 and the AIEE Lamme Medal for 1936, and has received a number of other awards for his achievements. He has been associated with the Westinghouse company since 1890.

W. M. White (M'21) manager and chief engineer of hydraulic department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been selected as one of the recipients of the "Modern Pioneer" awards of the National Association of Manufacturers. The award recognizes Doctor White's invention of the "Hydraucone" draft tube for hydraulic turbines, which increased power output and efficiency and reduced the cost of excavation for installations.

C. R. Higson (A'21, M'32) formerly superintendent of system distribution, Utah Power and Light Company, Salt Lake City, has been made special consultant on distribution engineering and operation for the entire system. He has been associated with the company since 1912 and had held his former position since 1928. **A. C. Kelm** (A'21, M'37) has been advanced from the position of Salt Lake division superintendent to that of system superintendent. He has been with the company since 1916, at Grace, Idaho, and Salt Lake City.

Vivien Kellems (A'30, M'36) president, Kellems Products, Inc., New York, N. Y., has been chosen by the Soroptimist clubs of New York as the outstanding woman in industry for 1940. Miss Kellems, who organized her own company for the manufacture of cable grips in 1928, is said to be the only woman manufacturer in the electrical industry.

E. M. Meyer (A'27) formerly chief electrical engineer, Porcelain Products, Inc., Parkersburg, W. Va., has been made commercial and industrial engineer for Victor Insulators, Inc., Victor, N. Y. He had been with the former company since 1930.

F. R. Lack (M'37), manager, specialty products division, Western Electric Company, New York, N. Y., has been elected a member of the board of directors of the Institute of Radio Engineers for 1940.

Obituary • • •

James Burke (A'93, M'03, F'13) retired chairman of the board, Burke Electric Company, Erie, Pa., and president of the Edison Pioneers, died January 21, 1940. He was born April 7, 1863, at London, Eng., and educated there, coming to New York in 1888. In 1889 he was employed at the Edison Machine Works, Schenectady, N. Y., in the testing department, and was assigned as assistant to Thomas A. Edison when the latter was at Schenectady. When the company's first student course was organized in 1889, Mr. Burke was the first to sign up for it. Later transferred to the engineering department he continued with the company and its successors, the Edison General Electric Company and General Electric Company, until 1894. During the next four years he was in private consulting practice in New York. In 1898 he became consulting engineer for the Bergmann Elektromotoren and Dynamo Works, Berlin, Germany, and in the same year gave up his consulting practice to become its technical director and chief engineer, a position he held until 1902, when he returned to private practice. In 1904 he formed and became president of the Burke Electric Company. He was president until 1928 and then chairman of the board until 1933, when he retired but continued to maintain an advisory interest in the company. He represented both the

AIEE and the National Electrical Manufacturers Association on the United States national committee of the International Electrotechnical Commission and was president of the Commission in 1935. He was well known as an inventor. He had served on the standards and electrical machinery committees of the AIEE, and was also a member of The American Society of Mechanical Engineers and the American Welding Society and past president of NEMA. He had been president of the Edison Pioneers for three years.

Arlington Pearl Little (A'09, M'14) professor of electrical engineering, Colorado School of Mines, Golden, died December 28, 1939. He was born at Clarenceville, Quebec, Can., December 17, 1879, and received the degrees of bachelor of science in electrical engineering (1901) and electrical engineer (1904) from the University of Vermont. He did graduate work also at George Washington University and Yale University. In 1901 and 1902 he was employed in the electrical department of the New England Telephone and Telegraph Company, Boston, Mass. He began his teaching career as assistant in electrical engineering at the Oklahoma Agricultural and Mechanical College, Stillwater, in 1903, leaving in 1906 to become assistant professor of electrical engineering at the University of Syracuse, Syracuse, N. Y. In 1909 he returned to Oklahoma A. and M. as associate professor of electrical engineering in charge of the electrical-engineering department. He was employed by the Bureau of Standards, Washington, D. C., 1914–18, as assistant physicist and later associate physicist, and 1918–19 was an associate professor at Yale University, New Haven, Conn. He had held his position at Colorado School of Mines since 1919. He was also a member of the Society for the Promotion of Engineering Education and an inventor.

George Albert Scoville (A'05, M'30) vice-president and general manager, Stromberg-Carlson Telephone Manufacturing Company, Rochester, N. Y., died January 14, 1940. He was born at Ironton, Mo., December 21, 1876, and studied electrical engineering at Stanford University. From 1898 to 1901 he was employed by Western Electric Company, Chicago, Ill.; from 1903 to 1905 in the testing laboratories of the Edison Electric Company (now Southern California Edison Company, Ltd.), Los Angeles, Calif. He returned to Western Electric for a short time for work on Pacific Coast installations, before becoming associated in 1905 with the Dean Electric Company (later the Garford Manufacturing Company), Elyria, Ohio, for which he was successively installation foreman, sales engineer, Pacific Coast resident engineer, and sales manager. He went with the Stromberg-Carlson Telephone Manufacturing Company in 1916, where he had charge of sales, sales engineering, installation, and advertising. He was a director of the company and also president of the Stromberg-Carlson Telephone Manufacturing Company of Canada, Ltd., president of the Scoville Mercantile Company, Atlanta, Ga., and vice-president of Bludworth, Inc., New York, N. Y. He was also a member of the Society of Automotive Engineers and the Institute of Radio Engineers.

William Henry Reynolds (A'04, M'26) retired, formerly in charge of electrical maintenance and construction, General Electric Company, Erie, Pa., died January 12, 1940. He was born April 10, 1867, at Lawrence, Kans., and received the degree of bachelor of science in electrical engineering from the University of Kansas in 1890. Following graduation he was employed by the Edison General Electric Company, in Denver Colo., and by the Thomson-Houston Company, at Chicago, Ill., both predecessors of General Electric. During 1891–92 he was with the Columbian Moving Sidewalk Company, Chicago, engaged on experimental installations and the following year was electrician for the St. Joseph and Benton Harbor (Mich.) Light and Power Company. He was associated with General Electric in St. Louis, Mo., 1893–96, and with the Missouri Edison Company, St. Louis, and the New Orleans and Western Railway, New Orleans, La., from 1896 to 1900, when he returned to General Electric at New York, N. Y. In 1910–11 he was with Canadian General Electric Company, Toronto, Ont., and in 1911 was transferred to the new plant of General Electric at Erie, Pa., where he continued until his retirement in 1930. He was chairman of the AIEE Erie Section 1935–36.

Paul James Ost (M'23) manager and chief engineer of the Electric Power Bureau, City of San Francisco, Calif., died December 30, 1939. He was born at Topeka, Kans., November 9, 1882, and attended the University of Kansas. In 1901 he was employed by the Atchison, Topeka, and Santa Fé Railway in the signal department, becoming engineering inspector, assistant maintenance engineer, and signal supervisor and assistant signal engineer. From 1907 to 1909 he was signal engineer for the Pacific Electric Railway, Los Angeles, Calif., and in 1909 entered the service of the City of San Francisco as assistant city engineer in charge of electrical work. Later he became chief electrical engineer, and when the Electric Power Bureau was organized he was made manager and chief engineer. He designed the city's fire-alarm system, had charge of engineering and equipment design for the municipal railway, and of the street lighting and municipal power and gas purchases for the city. He also designed and had charge of the power system of the Hetch Hetchy water supply project.

Martin E. Popkin (A'19) industrial consultant, New York, N. Y., died January 29, 1940. He was born at Le Havre, France, November 22, 1891, and studied at the Baron Rothschild Academy, Cairo, Egypt. He was employed on various electrical installations and in the laboratory of the Peram Chemical Corporation, New York, before becoming assistant technical examiner for the United States Department of Labor, New York, in 1917. He was personnel director for the Franklin Baker Company, New York, 1919–21, and industrial engineer for W. L. Churchill, 1921–23. The following year he served as consultant for the Warner Sugar Company, Miranda, Cuba, and from 1924 to 1928 was employed by J. Schoeneman, Inc., Baltimore, Md. Since 1929 he had been in private consulting practice, specializing in industrial design. He was the author of textbooks and technical articles and was also a member of The American Society of Mechanical Engineers.

Alfred Lewis Harrington (A'07), chief electrical engineer, Pittsburgh Plate Glass Company, Pittsburgh, Pa., died November 15, 1939, according to information recently received at Institute headquarters. He was born at Reading, Mass., May 6, 1880, and graduated in electrical engineering at Ohio State University in 1905. Following graduation he was employed by General Electric Company as an erecting engineer at Pittsburgh, Pa. Part of his work for that organization consisted of installing electric motors in one of the plants of the Pittsburgh Plate Glass Company. Later he was electrical superintendent for the Carolina Power and Light Company, Raleigh, N. C., and superintendent of electrical construction for the Phenix Utility Company, Hartsville, S. C. In 1919 he took the position with the Pittsburgh Plate Glass Company which he held until his death.

Joseph Herbert Shannon (M'25) assistant plant engineer, RCA Communications, Inc., New York, N. Y., died January 16, 1940. He was born in Ireland in December 1888, and received his technical education at Faraday House, London. During the period 1910–19 he was engaged in the construction and operation of radio stations in England, Canada, Newfoundland, Africa, and Arabia. He was engaged on power-station design and layout for the General Electric Company, Schenectady, N. Y., 1919–20, and in 1920 went with the Radio Corporation of America, New York, N. Y., as power-station designer. About ten years later he became assistant chief communications engineer for RCA Communications, and later assistant plant engineer.

Floyd S. Doxey (A'26) estimating engineer, Pacific Power and Light Company, Portland, Ore., died January 12, 1940. He was born in Salt Lake City, Utah, April 15, 1900, and received the degree of bachelor of science in electrical engineering at the University of Utah in 1925. After graduation he entered the student test course at General Electric Company, Schenectady, N. Y. He joined the staff of the Pacific Power and Light Company as a draftsman in 1927, becoming engineer in 1936 and estimating engineer in 1939.

Membership • •

Recommended for Transfer

The board of examiners, at its meeting on February 21, 1940, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Bellaschi, P. L., development engineer, Westinghouse Electric and Manufacturing Company, Sharon, Pa.

Fosdick, E. R., engineer, Federal Power Commission, Washington, D. C.

2 to Grade of Fellow

To Grade of Member

Brown, C. E., engineering checker, Pratt and Whitney Aircraft Company, East Hartford, Conn.
Buell, R. C., sponsor engineer, General Electric Company, Schenectady, N. Y.
Burr, H. B., telephone engineer, Wisconsin Telephone Company, Milwaukee.
Hilborn, D. S., senior staff engineer, Bell Telephone Company of Pennsylvania, Philadelphia.
Hubbard, D. C., chief of research, A. B. Chance Company, Centralia, Mo.
Johanson, E. A., associate electrical engineer, Tennessee Valley Authority, Knoxville, Tenn.
Johnson, F. E., assistant to superintendent, New Orleans Public Service, Inc., New Orleans, La.
Moxey, L. W., 3rd, secretary, Keller-Pike Company, Philadelphia, Pa.
Oklund, A. L., design engineer, Louis Allis Company, Milwaukee, Wis.
Osborn, B. K., assistant professor of electrical engineering, Michigan State College, East Lansing.
Shober, W. M., electrical engineer, Aluminum Company of America, Alcoa, Tenn.
Stoughton, C. B., electrical engineer, Aluminum Company of America, Alcoa, Tenn.
Uhl, H. C., assistant district engineer, General Electric Company, Atlanta, Ga.
Wallis, C. M., assistant professor of electrical engineering, University of Missouri, Columbia.

14 to Grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical Districts. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before March 31, 1940, or May 31, 1940, if the applicant resides outside of the United States or Canada.

United States and Canada

1. North Eastern

Aaltonen, L. O. T., Narragansett Electric Company, Providence, R. I.
Abbott, S. R., Heald Machine Company, Worcester, Mass.
Black, N. L., Central New York Power Corporation, Syracuse, N. Y.
Chapman, J. H., Public Service Company of New Hampshire, Somersworth.
Comsey, K. W., Hygrade Sylvania Corporation, Salem, Mass.
Dalton, B. J., General Electric Company, Schenectady, N. Y.
Deibert, C. R., Massachusetts Institute of Technology, Cambridge.
Dickinson, R. H., Hygrade Sylvania Corporation, Salem, Mass.
Edwards, M. A. (Member), General Electric Company, Schenectady, N. Y.
Francis, J. T., 716 Rockdale Avenue, New Bedford, Mass.
Gervais, W. A., Boston Edison Company, Dorchester, Mass.
Hall, W. H., General Electric Company, Lynn, Mass.
Hokanson, H. T., General Electric Company, Schenectady, N. Y.
Houston, R. K., Brown University, Providence, R. I.
Jackson, F. R., Jr., General Electric Company, Pittsfield, Mass.
Kimball, R. B., General Electric Company, Schenectady, N. Y.
Klumb, R. E., General Electric Company, Schenectady, N. Y.
Kudravetz, M. K., United States War Department, Waterbury, Conn.
Lituchy, N. J., Pratt and Whitney Aircraft, East Hartford, Conn.
Magruder, H. W., General Electric Company, Schenectady, N. Y.
Mann, W. B., General Electric Company, Lynn, Mass.
Markel, M., Markel Electric Products, Inc., Buffalo, N. Y.
Marzullo, A. A., 42 Townsend Avenue, New Haven, Conn.
Mazur, J. G., Yale and Towne Manufacturing Company, Stamford, Conn.
McAteer, L. F., General Electric Company, Pittsfield, Mass.
McCarty, R. W., Eastman Kodak Company, Rochester, N. Y.
McComb, R. D., General Electric Company, Schenectady, N. Y.
Messimer, W. D., American Steel and Wire Co., Worcester, Mass.
Miller, W. E., General Electric Company, Schenectady, N. Y.
Miner, G. L., Builders Iron Foundry, Providence, R. I.
Mitchell, W. C., Jr., General Electric Company, Lynn, Mass.
Norberg, A. V., General Electric Company, Pittsfield, Mass.
Parshall, H. M., Rensselaer Polytechnic Institute, Troy, N. Y.
Persia, P. M., General Railway Signal Company, Holley, N. Y.
Pinkerton, D. C., General Electric Company, Schenectady, N. Y.
Powers, L. F., Central New York Power Corporation, Watertown, N. Y.
Remscheid, E. J. (Member), General Electric Company, Schenectady, N. Y.
Revercomb, H. E., Eastman Kodak Company, Rochester, N. Y.
Reynolds, R. H., Jr., General Electric Company, Schenectady, N. Y.
Rosenberg, S. L., Department of Public Works, Albany, N. Y.
Schwedes, W. H., General Electric Company, Schenectady, N. Y.
Silvey, J. O., Lombard Governor Corporation, Ashland, Mass.
Smith, C. H., General Electric Company, Pittsfield, Mass.
Smith, E. P., General Electric Company, Schenectady, N. Y.
Stetson, F. H., 24 Grove Street, Bangor, Maine.
Stuart, R. M., Clapp Instrument Company, Webster, Mass.
Taylor, N. H., Lombard Governor Corporation, Ashland, Mass.
Thiry, W. C., Bethlehem Steel Company, Lackawanna, N. Y.
Uren, D. E., General Electric Company, Schenectady, N. Y.
Uttal, J. A., General Electric Company, Schenectady, N. Y.
Wantzelius, O. G., General Electric Company, Schenectady, N. Y.
West, W. W., Narragansett Electric Company, Providence, R. I.
Wilson, D. G., Sealand Corporation, Bridgeport, Conn.

2. Middle Eastern

Adams, E. M., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Armstrong, D. E., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Aspinwall, R. E., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Baird, L. L., General Electric Company, Philadelphia, Pa.
Barnes, R. D., Rural Electrification Administration, Washington, D. C.
Bates, E. L., Philadelphia Electric Company, Philadelphia, Pa.
Bearer, P. J., Gibson Electric Company, Pittsburgh, Pa.
Berrier, T., American Telephone and Telegraph Company, Washington, D. C.
Biebesheimer, W. B., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Carvellas, J. N., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Chapman, J. J., General Electric Company, Philadelphia, Pa.
Clark, J. A., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Coffin, W. R., 1318 Singer Place, Wilkinsburg, Pa.
Collins, R. K., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Colteryahn, H. C., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Davies, S., Hickok Electrical Instrument Company, Cleveland, Ohio.
Day, W. M., Consolidated Gas and Electric Light Company, Baltimore, Md.
DeMerit, M. (Member), West Penn Power Company, Pittsburgh, Pa.
Doda, C. J., Line Material Company, Zanesville, Ohio.
Donaldson, T., J. P. Manypenny, Philadelphia, Pa.
Dudek, R. C., United Broadcasting Company, Cleveland, Ohio.
Ellis, B. R., Westinghouse Electric and Manufacturing Company, Philadelphia, Pa.
Engel, F. H. (Member), RCA Manufacturing Company, Inc., Washington, D. C.
Ferree, H. M., General Electric Company, Nela Park, Cleveland, Ohio.
Fischer, F. P., Chesapeake and Potomac Telephone Company, Washington, D. C.
Flockencier, W. E., North Electric Manufacturing Company, Galion, Ohio.
Ford, W. B., Jr., Allis-Chalmers Manufacturing Company, Pittsburgh, Pa.
Freehafer, C. R. (Member), Bell Telephone Company of Pennsylvania, Philadelphia, Pa.
Gilkeson, R. F., Philadelphia Electric Company, Philadelphia, Pa.
Goldman, A. W., Appalachian Electric Power Company, Cabin Creek, W. Va.
Green, W. M., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Gregory, L. W., Westinghouse Electric and Manufacturing Company, Baltimore, Md.
Gulden, W. W., Cincinnati and Suburban Bell Telephone Company, Cincinnati, Ohio.
Haber, E. H., Electric Service Supplies Company, Philadelphia, Pa.
Haimowitz, B., Bethlehem Steel Company, Bethlehem, Pa.
Hanuschak, M., Ohio Edison Company, Youngstown.
Happy, J., Ohio Public Service Company, Port Clinton.
Hayes, E. M., Jr., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Hays, F. D., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Headley, C. B., Westinghouse Lamp Manufacturing Company, Trenton, N. J.
Heine, L. J. (Member), Mack Manufacturing Corporation, Allentown, Pa.
Hembree, H. G., Rural Electrification Administration, Washington, D. C.
Higgins, T. A., Carnegie-Illinois Company, Monongahela, Pa.
Hofing, F. H., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Holman, F. H., Master Electric Company of Dayton, Cleveland, Ohio.
Houck, H. E. (Member), E. I. du Pont de Nemours and Company, Wilmington, Del.
Hovarka, E., Ohio Bell Telephone Company, Cleveland.
Hyle, S. J., Duquesne Light Company, Pittsburgh, Pa.
Jackson, R., Jr., Philco Corporation, Philadelphia, Pa.
Johnson, H. D., Hygrade Sylvania Corporation, Emporium, Pa.
Kasch, H., General Electric Company, Philadelphia, Pa.
Keck, L. E., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Kevern, G. M., United States Army Air Corps, Dayton, Ohio.
Kiefer, D. B., Pittsburgh Coke and Iron Company, Neville Island, Pa.
Kleinhofer, B. A., Electric Service Supplies Company, Philadelphia, Pa.
Kolecki, A., Ohio Crankshaft Company, Cleveland, Ohio.
Ludwig, V. A., Ames Baldwin Wyoming Company, Parkersburg, W. Va.
Lyon, S. B., Monitor Controller Company, Baltimore, Md.
MacMillan, L. W., Jr., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Maleski, M., Babcock and Wilcox Company, Barberton, Ohio.
Mansfield, R. L., Carnegie Institute of Technology, Pittsburgh, Pa.
Martin, R. E., General Electric Company, Philadelphia, Pa.
McHugh, J. B., General Electric Company, Philadelphia, Pa.
McKendree, J. H., Jr., Pennsylvania Railroad Company, Philadelphia, Pa.
McMahon, R. E., 827 North Broad Street, Woodbury, N. J.
Meeker, W. F., United States Engineers, Cincinnati, Ohio.
Merrill, R. L., The Autocall Company, Shelby, Ohio.
Meyer, W. G., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Meyers, T. E., Wolfe and Mann Manufacturing Company, Baltimore, Md.
Middough, W. V., Laganke Electric Company, Cleveland, Ohio.
Milde, N. H., Cleveland Electric Illuminating Company, Cleveland, Ohio.
Miller, F. L., Jr., General Electric Company, Erie, Pa.
Moore, R. W., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Morris, W. C., Rural Electrification Administration, Washington, D. C.
Mothersead, C. T., Chesapeake and Potomac Telephone Company, Washington, D. C.
Muller, F. A., Glenn L. Martin Company, Baltimore, Md.
Myers, A. S., Jr., Electric Heating Equipment Company, Philadelphia, Pa.
Newcomer, G. H. (Member), Pennsylvania Railroad, Altoona, Pa.
Niemeyer, H. F., Chesapeake and Potomac Telephone Company, Washington, D. C.
Ogram, R. L., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
O'Neill, H. T., Jr., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Pedgarney, J. S., 6531/2 Mulberry Avenue, Clarksburg, W. Va.
Pehl, M. M., Ohio Brass Company, Mansfield, Ohio.
Perry, C. S., Jr., RCA Manufacturing Company, Inc., Camden, N. J.
Phillips, W. C., Jr., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Powell, W. E., 176 Mill St., Athens, Ohio.
Prince, R. W., Jr., 3172 18 Street, N. W., Washington, D. C.
Quinn, J. C., 435 Breck Street, Scranton, Pa.
Quinn, J. M., J. W. Mills Electric Company, Scranton, Pa.
Rader, R. E., Rural Electrification Administration, Washington, D. C.

Reed, O. W. B., Jr., care Jansky and Bailey, Washington, D. C.
Reitz, N. J., Breinigsville R. D. #2, Seipstown, Pa.
Rhodes, M. D., Rochester and Pittsburgh Coal Company, Indiana, Pa.
Robertson, H. C., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Schaffner, G. W., Bradley Company, Washington, D. C.
Schleinkofer, G. N., Bell Telephone Company of Pennsylvania, Philadelphia, Pa.
Shackelford, F. W., General Electric Company, Philadelphia, Pa.
Shafer, M. R., Jr., National Bureau of Standards, Washington, D. C.
Sherron, R. J., Jr., Pan American Airways, Baltimore, Md.
Silvester, W. R., Box 52, Princeton, N. J.
Smith, H. R., Rural Electrification Administration, Washington, D. C.
Smith, L. E., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Spethmann, E. C., General Electric Company, Erie, Pa.
Tepel, G. E., The Austin Company, East Cleveland, Ohio.
Terrel, R. D., 232 North High Street, Columbus, Ohio.
Tibbetts, W. D., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Tucker, R. J., Jr., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Van Sciver, H. D., II, care E. G. Budd Manufacturing Company, Philadelphia, Pa.
Wanamaker, R. L., Lincoln Electric Company, Cleveland, Ohio.
Warshaw, H. D., Drexel Institute of Technology, Philadelphia, Pa.
Westermeyer, P. H., Columbia Engineering Corporation, Cincinnati, Ohio.
Wetzer, W. R., 1724 P Street, N. W., Washington, D. C.
Whitescarver, R. S., Route #2, Grafton, W. Va.
Willett, L. G., Chesapeake and Potomac Telephone Company, Washington, D. C.
Williams, E. M., Pennsylvania State College, State College, Pa.
Winter, A. F., 500 Maxwell Street, Charleston, W. Va.
Winterich, O. C., Westinghouse Electric and Manufacturing Company, Cleveland, Ohio.
Wright, G. L., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Wynn, J. H., Rosenblatt and Hunt, Charleston, W. Va.
Yagelowich, S. L., Westinghouse Electric and Manufacturing Company, Sharon, Pa.

3. New York City

Agress, M. C., A. W. Franklin Manufacturing Corporation, New York, N. Y.
Anderson, J. J., United States Rubber Company, New York, N. Y.
Andrasko, J. P., New York University, New York, N. Y.
Aronow, S., United States Signal Corps, Fort Monmouth, Oceanport, N. J.
Badgley, R. H., Bell Telephone Laboratories, Inc., New York, N. Y.
Basten, J. D., Kingston, N. Y.
Bateman, E. J., General Electric Company, New York, N. Y.
Bjornson, W. G., Cornell Dubilier Electric Corporation, South Plainfield, N. J.
Bollman, J. H., Bell Telephone Laboratories, Inc., New York, N. Y.
Braida, L., Consolidated Edison Company of New York, Inc., New York, N. Y.
Brazdionis, J., Signal Engineering and Manufacturing Company, New York, N. Y.
Brooks, L. P., International Telephone and Telegraph Company, New York, N. Y.
Brynes, K., 4715 Carpenter Avenue, New York, N. Y.
Buckles, R. A., Jr., John Wiley and Sons, Inc., New York, N. Y.
Butterweck, H. W., 138-02—135 Avenue, South Ozone Park, N. Y.
DeWitt, H. W. (Member), New York Telephone Company, New York, N. Y.
Erickson, L. E., Westinghouse Electric and Manufacturing Company, Newark, N. J.
Fontana, R. E., 34-20—32 Street, Astoria, Long Island, N. Y.
Frawley, W. P., Bell Telephone Laboratories, Inc., New York, N. Y.
Gorin, L., New York City Board of Transportation, New York, N. Y.
Gove, K. G., Commercial Radio Sound Corporation, New York, N. Y.
Groome, P. E., American Telephone and Telegraph Company, New York, N. Y.
Gruenberg, H., Gruenberg Electric Company, Inc., New York, N. Y.
Halbrook, W. W., Bell Telephone Laboratories, Inc., New York, N. Y.
Hallenbeck, F. J., Bell Telephone Laboratories, Inc., New York, N. Y.
Hecht, B., 50 Hamilton Place, New York, N. Y.
Hubbard, C. G., Arma Corporation, Brooklyn, N. Y.
Huldschiner, G. (Member), 414 West 120 Street, New York, N. Y.
Huse, R. A., Public Service of New Jersey, Kearny Meadows.
Hutchins, S. E., Long Island Lighting Company, Mineola, L. I., N. Y.
Iannarone, R. P., Diehl Manufacturing Company, Elizabethport, N. J.
Jackson, B. A., The Lummus Company, New York, N. Y.
Jackson, J. A., Westchester Lighting Company, Mount Vernon, N. Y.
Jeffords, J. M., International Soundphotos, New York, N. Y.
Jude, G. F., 282 East Gunhill Road, New York, N. Y.
Kang, B. P., General Cable Corporation, Perth Amboy, N. J.
Kenyon, R. W., Electric Storage Battery Company, New York, N. Y.
Korenski, F. J., 358 Pulaski Street, Port Richmond, S. I., N. Y.
Krause, A. J., Aeronautical Radio Company, Roosevelt Field, L. I., N. Y.
Langborgh, H. V., Public Service Electric and Gas Company, Newark, N. J.
Leva, F. L., United States Army Signal Corps, Fort Monmouth, N. J.
Lindblad, C. W., Sperry Gyroscope Company, Inc., Brooklyn, N. Y.
Lovejoy, E. E., Public Service Electric and Gas Company of New Jersey, Irvington.
Marotta, J. F., United States Army Signal Corps, Fort Monmouth, Oceanport, N. J.
McDavitt, M. B. (Member), Bell Telephone Laboratories, Inc., New York, N. Y.
Mele, F., Gibbs and Cox, New York, N. Y.
Merchant, R., Wallace and Tiernan Company, Inc., Belleville, N. J.
Muller, J. W., Box 144, Hawthorne, N. Y.
Nearing, H. H., Public Service of New Jersey, Newark.
Neureither, L. A., The North American Company, New York, N. Y.
Nycz, J. C., Westinghouse Electric and Manufacturing Company, Newark, N. J.
Oravetz, A. S., Tung-Sol Lamp Works, Inc., Newark, N. J.
Outlaw, E. G., Public Service Electric and Gas Company, Kearny, N. J.
Papritz, G. A., 235-21—137th Avenue, Rosedale, N. Y.
Parry, J. S., Jr., Westinghouse Electric and Manufacturing Company, Newark, N. J.
Pullen, H. V. D., Weston Electrical Instrument Corporation, Newark, N. J.
Rea, J. C., Jr., Phelps Dodge Copper Products Corporation, Bayway, N. J.
Sanders, M. F., Electric Advisers, New York, N. Y.
Schoenfuss, A. F., Columbia Broadcasting System, Inc., New York, N. Y.
Shapiro, I., 1551 Sheridan Avenue, Bronx, N. Y.
Smith, C. H., Jr., Federal Telegraph Company, Newark, N. J.
Steinhauser, C. P., 69 Adrian Avenue, New York, N. Y.
Sutherland, J. K., Rockefeller Center, Inc., New York, N. Y.
Tenenbaum, F., Jefferson-Travis Radio Manufacturing Corporation, Baldwin, N. Y.
Thaler, S., 588 Midwood Street, Brooklyn, N. Y.
Throndsen, E. C., 1074 East 38 Street, Brooklyn, N. Y.
Todd, H. T., General Electric Company, New York, N. Y.
Wolferz, A. H. (Member), Weston Electrical Instrument Corporation, Newark, N. J.
Yosenleirtz, P. J., Long Island Lighting Company, Roslyn, N. Y.

4. Southern

Arndt, F. L., South Carolina Electric and Gas Company, Columbia.
Bluethenthal, H., Jr., 1704 Market Street, Wilmington, N. C.
Boykin, J. H., Southern Railway System, Ludlow, Ky.
Broussard, T. G., Louisiana Power and Light Company, West Monroe.
Brown, T. W., Louisiana Power and Light Company, Algiers.
Bryan, C. E., Electrical Testing Laboratory, TVA, Wilson Dam, Ala.
Cayce, E. E., Virginia Electric and Power Company, Virginia Beach.
Chaney, Y. T., Trumbull Electric Manufacturing Company, Ludlow, Ky.
Choate, R. I., Kentucky and West Virginia Power Company, Pikeville, Ky.
Cormack, W. J., Jr., Federal Power Commission, Atlanta, Ga.
Creagh, J. W. R., Memphis Light, Gas and Water Division, Memphis, Tenn.
Crowder, J. A., Knoxville Electric Power and Water Board, Knoxville, Tenn.
Crumly, H. J., Tennessee Coal Iron and Railroad Company, Fairfield, Ala.
Davis, R. T., United States Army Corps of Engineers, Fort Belvoir, Va.
deGruy, W. V., New Orleans Public Service, Inc., New Orleans, La.
Dinius, P. S., Ashland Oil and Refining Company, Ashland, Ky.
Dominick, J. B., Duke Power Company, Spencer, N. C.
Elder, W. W., Jr., Southern Bell Telephone and Telegraph Company, Louisville, Ky.
Gambell, C. E., Knoxville Electric Power and Water Board, Knoxville, Tenn.
Hall, R. S., Jr., Mississippi Power and Light Company, McComb.
Haviland, R. P., Schlumberger Well Surveying Corporation, Houma, La.
Higgins, J. S., Jr., Celanese Corporation of America, Narrows, Va.
Hottinger, S. E., Jr., Public Works Administration, New Orleans, La.
Karr, E. P., Kentucky Public Service Commission, Frankfort.
Lawrence, M. O., Jr., Georgia Power Company, Atlanta.
Low, B. D., The Carter Oil Company, Greenwood, Miss.
Newman, J. B., 2nd, Virginia Military Institute, Lexington.
O'Brien, K. W. (Miss), National Advisory Committee for Aeronautics, Langley Field, Va.
Page, D. D., Mengel Company, Inc., Winston Salem, N. C.
Pharis, W. W., Lee Telephone Company, Martinsville, Va.
Picou, F. T., Thibodaux, La.
Pratt, J. R., Sigma Phi Epsilon Fraternity, Richmond, Va.
Pritchard, H. E., Jr., New Orleans Public Service, Inc., New Orleans, La.
Ramsey, A. K., Jr., Louisiana State University, University, La.
Reed, H. L., H. C. Biglin Company, Atlanta, Ga.
Shepherd, J. F., Ripley, Miss.
Sifford, M. G., University of Tennessee, Knoxville.
Stevenson, W. D., Jr., Clemson College, Clemson, S. C.
Taylor, R. S., Ellisville, Miss.
Taylor, W. N., Duke Power Company, Charlotte, N. C.
Tiedemann, J. J., Jr., Louisiana Power and Light Company, New Orleans.
Toomer, F. S., Mississippi State Highway Department, Fulton.
Williams, J. B., Louisville Gas and Electric Company, Louisville, Ky.
Zimmerman, M. V. (Member), Commonwealth and Southern Corporation, Birmingham, Ala.

5. Great Lakes

Baldwin, J. N., Commonwealth Edison Company, Chicago, Ill.
Beears, D. G., Electro-Motive Corporation, La-Grange, Ill.
Berkheiser, H. A., Indiana Service Corporation, Fort Wayne.
Best, P. B., Jr., A. G. Redmond Company, Owosso, Mich.
Black, S. A., United States Rubber Company, Detroit, Mich.
Boehne, V. E., The Glidden Company, Chicago, Ill.
Boulson, C. E., Jay Samuel Hartt, Madison, Wis.
Brewster, F. C., Brewster Radio Company, Joliet, Ill.
Brierley, W. G., Jr., Commonwealth Edison Company, Chicago, Ill.
Brown, J. S., Indiana and Michigan Electric Company, South Bend, Ind.
Carrothers, G. H., A. G. Redmond Company, Owosso, Mich.
Cartotto, E., Illinois Testing Laboratories, Inc., Chicago.
Cento, C. R., P. O. Box 208, Carthage, Ill.
Close, M. J., Jr., Gillette Rubber Company, Eau Claire, Wis.
Conn, G. E., Jr., Allis-Chalmers Manufacturing Company, Milwaukee, Wis.
Conrad, R. S., Collins Radio Company, Cedar Rapids, Iowa.
Cooper, D. W., Commonwealth Edison Company, Chicago, Ill.
Cox, E. J. R., Automatic Electric Company, Chicago, Ill.
Davies, E. H., Allen-Bradley Company, Milwaukee, Wis.
Dennis, R., Jr., Ford Motor Company, Iron Mountain, Mich.
Dewenter, J. C., Public Service Company of Indiana, Lafayette.
Dillow, N. E., Illinois Iowa Power Company, Champaign, Ill.
Doenges, F. G., Public Service Company of Indiana, Indianapolis.
Dragsten, P., Commonwealth Edison Company, Chicago, Ill.
Elliott, G., Automatic Electric Company, Chicago, Ill.
Ellsworth, C. D., Underwriters Laboratories, Inc., Chicago, Ill.
Epstein, B., Marquette Electric Switchboard Company, Chicago, Ill.
Farquharson, G. M., Interstate Power Company, Dubuque, Iowa.
Fisher, E. J., 2521 South Central Park Avenue, Chicago, Ill.
Forrestal, R. P., Cutler-Hammer, Inc., Milwaukee, Wis.
Freeman, C. F., Illinois Bell Telephone Company, Chicago.
Gibbs, F. J., Consumers Power Company, Alma, Mich.
Goodrich, F. B., Corn Products Refining Company, Argo, Ill.
Grandstaff, O. D. (Member), Associated Electric Laboratories, Inc., Chicago, Ill.
Hagen, E. M., American Steel and Wire Company, Waukegan, Ill.
Halter, A. C., Allis-Chalmers Manufacturing Company, West Allis, Wis.
Hebson, J. D., Associated Research, Inc., Chicago, Ill.
Hendrick, F. C., Kenneth R. Brown, Des Moines, Iowa.
Hunsader, Y., Square D Company, Milwaukee, Wis.
Jones, J. E. (Member), Cutler-Hammer, Inc., Milwaukee, Wis.

Kerschler, A. E., A. G. Redmond Company, Owosso, Mich.
Kotal, J. R., Dryden Rubber Company, Chicago, Ill.
Lehmann, C. C., 12385 Birwood, Detroit, Mich.
Lippitt, V. G., Northwestern University, Evanston, Ill.
Merik, E. F., Jefferson Electrical Company, Bellwood, Ill.
McConnell, M. E., Carnegie-Illinois Steel Corporation, Gary, Ind.
Meier, R. A., Pennsylvania Railroad, Chicago, Ill.
Miller, M. L., Indiana and Michigan Electric Company, South Bend, Ind.
Moore, E. R. (Member), Detroit Edison Company, Detroit, Mich.
Newburgh, H., University of Michigan, Ann Arbor.
Newman, J. E., Indiana and Michigan Electric Company, Buchanan, Mich.
Odell, R. C., Allis-Chalmers Manufacturing Company, Milwaukee, Wis.
Olson, S. A., Public Service Company of Northern Illinois, Chicago.
Onstad, N., Allis-Chalmers Company, Milwaukee, Wis.
Owens, V. R., National Youth Administration, Cassidy Lake, Chelsea, Mich.
Patton, C. C., Sangamo Electric Company, Springfield, Ill.
Pies, J. R., Rose Polytechnic Institute, Terre Haute, Ind.
Pomazal, J. W., Westinghouse Electrical Supply Company, Milwaukee, Wis.
Reece, W. A., Consumers Power Company, Jackson, Mich.
Scarbrough, J. D., Detroit Edison Company, Detroit, Mich.
Schofield, H. V., Illinois Bell Telephone Company, Chicago.
Schreiber, W. E., Illinois Bell Telephone Company, Waukegan.
Schuette, R. E., Barber Colman Company, Rockford, Ill.
Sorvaag, C. M., Automatic Electric Company, Chicago, Ill.
Stone, L. N., Caterpillar Tractor Company, Peoria, Ill.
Strapulos, C. M., Delco Radio Division, Kokomo, Ind.
Summers, I. A., Southern Indiana Gas and Electric Company, Evansville, Ind.
Terp, V. E. S., Quam Nichols Company, Chicago, Ill.
Treadwell, M. E., Michigan Public Service Company, Scottville.
Truemner, R. O., Hevi Duty Electric Company, Milwaukee, Wis.
Tung, S. T., P. O. Box 522, West Lafayette, Ind.
Van Den Berge, L., Tri-County Telephone Company, South Haven, Mich.
Wahlert, M. R., 35-B Quadrangle, Iowa City, Iowa.
Ward, J. B., Commonwealth Edison Company, Chicago, Ill.
Wentz, J. G., Interstate Power Company, Dubuque, Iowa.
Williamson, R. J., Carnegie Illinois Steel, Chicago, Ill.
Yoder, R. D., Delco Products, Dayton, Ohio.

6. North Central

Chamberlin, E. C., Jr., Western Union Telegraph Company, Omaha, Nebr.
Pottorf, J. A., General Public Utilities, Inc., Deadwood, S. Dak.
Repstein, C. K., 112 West Elizabeth, Pierre, S. Dak.
Sorensen, A. A., care H. S. Nixon, Omaha, Nebr.
Wallingford, L. E., Nebraska Power Company, Omaha.
Whaley, R. H., Nebraska Power Company, Omaha.
White, R. V., Nebraska Power Company, Omaha.

7. South West

Anderson, N. W., Reda Pump Company, Bartlesville, Okla.
Atlee, T. G., Jr., Texas Power and Light Company, Dallas.
Betts, A. L., Gulf States Utilities Company, Beaumont, Tex.
Bevins, M. W., Public Service Company of Oklahoma, Tulsa.
Clarke, W. R., Jr., Century Electric Company, St. Louis, Mo.
Clatterbaugh, F. C., Kansas City Power and Light Company, Kansas City, Mo.
Culley, M. H., Lower Colorado River Authority, Austin, Tex.
Drake, C. J., Kansas Gas and Electric Company, Wichita.
Dupree, G. W., Missouri Utilities Company, Cape Girardeau.
Fillmer, H. H., Missouri Electric Power Company, Marshfield.
Gee, K. C., Schlumberger Well Surveying Corporation, Houston, Tex.
Greenlees, C. R., Jr., Kansas Gas and Electric Company, Wichita.
Harris, R. M., Jr., Dallas Power and Light Company, Dallas, Tex.
Headrick, J. M., Petty Gravity Surveys, Inc., San Antonio, Tex.
Henley, B. H., 945 Ohio, Lawrence, Kans.
Herron, J. E., Century Electric Company, St. Louis, Mo.
Hilderbrand, E. A., E. Andrew Hilderbrand Sound Equipment Service, Dallas, Tex.
Hood, T. L., Petty Geophysical Engineering Company, San Antonio, Tex.
Hornbeck, T. D., Board of Education, Oklahoma City, Okla.
Hutchison, D. P., Southwestern Bell Telephone Company, Wichita, Kans.
James, R. L., Arkansas Power and Light Company, Pine Bluff.
Kendall, J. M., Geophysical Research Corporation, Tulsa, Okla.
Kershner, S. W., Texas Pipe Line Company, Houston, Tex.
Kimmel, P. H., Century Electric Company, St. Louis, Mo.
Lane, C. A., Jr., 4104 Harrison, Kansas City, Mo.
Lindgren, W. F., Court Street, Hot Springs, S. Dak.
McGregor, T. C., Southwestern Bell Telephone Company, Dallas, Tex.
McHale, J. P., Western Electric Company, Inc., Dallas, Tex.
Menees, B. M., Arkansas Power and Light Company, Searcy.
Mitchell, J. D., Jr., Westinghouse Electric and Manufacturing Company, St. Louis, Mo.
Morrison, M. M., Snoair Company, Dallas, Tex.
Movitz, P., Siebenthaler Manufacturing Company, Kansas City, Mo.
Mueller, W. J., Century Electric Company, St. Louis, Mo.
O'Halloran, W. R., Kansas City Power and Light Company, Kansas City, Mo.
Pence, M. B., Petty Geophysical Engineering Company, San Antonio, Tex.
Phillips, C. S., Emerson Electric Manufacturing Company, St. Louis, Mo.
Rex, D. F., 310 East Elm Street, Wichita, Kans.
Richardson, E. J., Arkansas General Utilities Company, Warren, Ark.
Rosenquist, R. T., Black and Veatch, Kansas City, Mo.
Shea, W. J., Essex Wire Corporation, St. Louis, Mo.
Spears, E. C., Westinghouse Electric and Manufacturing Company, Tulsa, Okla.
Stewart, R. M., Phillips Petroleum Company, Phillips, Tex.
Thompson, B. F., Public Service Company of Oklahoma, Tulsa.
Vogel, C. E., E. T. Archer Company, Kansas City, Mo.
Westcott, H. S., Jr., 3808 Maplewood, Dallas, Tex.
Wimer, C. J., Dallas Power and Light Company, Dallas, Tex.
Wristen, C. E., The Winkler-Koch Engineering Company, Wichita, Kans.
Yavitz, M., S. C. Sachs Company, St. Louis, Mo.

8. Pacific

Bates, G., Trumbull Electric Manufacturing Company, San Francisco, Calif.
Breitenbach, P., Pacific Gas and Electric Company, Emeryville, Calif.
Buss, R. R., Heintz and Kaufman, Ltd., South San Francisco, Calif.
Chesson, G. H., Southern California Edison Company, Ltd., Big Creek, Calif.
Coffee, H. T., Los Angeles Bureau of Power and Light, Los Angeles, Calif.
Coughlin, D. E., Permanente Corporation, San Jose, Calif.
Curtis, T. E., Pacific Gas and Electric Company, Oakland, Calif.
Dibble, E. S., General Electric Company, Los Angeles, Calif.
Dyer, D. B., Imperial Irrigation District, Imperial, Calif.
Ginzton, E. L., Stanford University, Stanford, Calif.
Goette, C. A., Pacific Gas and Electric Company, Oakland, Calif.
Greenwood, A. I., Phelps Dodge Corporation, Clarkdale, Ariz.
Grotts, H. J., Santa Cruz Portland Cement Company, Davenport, Calif.
Hannon, A. L., North American Aviation, Inglewood, Calif.
Heath, F. S., Jr., 1363 Sonora Avenue, Glendale, Calif.
Heller, A., Box L, Bishop, Calif.
Lovell, N. M., Tucson Gas, Electric Light and Power Company, Tucson, Ariz.
Ludekens, L. E., Southern California Edison Company, Ltd., Los Angeles, Calif.
Morton, J. T., Jr., Stanford University, Stanford, Calif.
Olivar, J. G., P. O. Box 1945, Tucson, Ariz.
Perlewitz, C. M., Bryant Electric Company, Los Angeles, Calif.
Peter, B. L., Pacific Gas and Electric Company, Fall River Mills, Calif.
Schmid, R. C., Los Angeles Bureau of Power and Light, Los Angeles, Calif.
Simmonds, W. E., Barium Products, Ltd., Modesto, Calif.
Smaus, L. H., Pacific Gas and Electric Company, San Mateo, Calif.
Steinback, E. W., 1734—23 Avenue, San Francisco, Calif.
Stevens, V. D., Central Arizona Light and Power Company, Phoenix, Ariz.
Stewart, C., Jr., RCA Communications, Inc., Point Reyes, Calif.
Stratford, J. P. (Member), Bureau of Power and Light, Los Angeles, Calif.
Sylvester, G. E., Consolidated Aircraft Corporation, San Diego, Calif.
Watkins, W. F. (Member), Walt Disney Productions, Burbank, Calif.
Wheeler, H. J. (Member), General Electric Company, Los Angeles, Calif.
Zukerman, L. G., Lockheed Aircraft Corporation, Burbank, Calif.

9. North West

Allen, J. F., Pacific Power and Light Company, Portland, Ore.
Ashton, R. E., Utah Power and Light Company, Salt Lake City.
Chambers, R. O., Chicago Milwaukee St. Paul and Pacific Railroad, Seattle, Wash.
Conn, J. T., University of Washington, Seattle.
Daniels, H. A., Northwestern Electric Company, Vancouver, Wash.
Davis, G. A., Washington Water Power Company, Spokane.
Dennis, K. R., United States Army, Fort Worden, Wash.
Dingler, J. B., Washington Water Power Company Spokane.
George, G. R., Washington Water Power Company, Spokane.
Jarvis, J. R., Utah Power and Light Company, Salt Lake City.
Kaehler, E. M., Pacific Power and Light Company, Yakima, Wash.
Kegg, K. L., United States Engineers, Bonneville, Ore.
Kelly, R. C., Washington Water Power Company, Spokane.
Lambert, J. L., Pend Oreille Electric Co-operative, Inc., Newport, Wash.
MacLean, T. W., Washington Water Power Company, Spokane.
McCourt, A. R., Montana Power Company, Butte.
Munakata, Y., Puget Sound Power and Light Company, Seattle, Wash.
Olsen, E. H., Pacific Power and Light Company, Portland, Ore.
Peterson, G. M., Pacific Power and Light Company, Portland, Ore.
Pollard, A. L. (Member), Puget Sound Power and Light Company, Seattle, Wash.
Ries, R. R., Washington Water Power Company, Spokane.
Smith, L. K., Portland General Electric Company, Portland, Ore.
Sparling, T. E., Northwestern Electric Company, Vancouver, Wash.
Straub, H., Crown Willamette Paper Company, Camas, Wash.
Torgerson, H. O., Washington Water Power Company, Spokane.
Uhden, C., Washington Water Power Company, Spokane.
Williamson, E. W. (Member), O. A. Carlson Electric Company, Seattle, Wash.

10. Canada

Baranovsky, G., Canadian General Electric Company, Toronto, Ont.
Bartlett, E. H., Canadian General Electric Company, Peterboro, Ont.
Bentley, D. R., 340 Kingston Crescent, Winnipeg.
Coulson, A., University of British Columbia, Vancouver.
Erlebach, G. B., 2466 West 5th Avenue, Vancouver, B. C.
French, F. L., Saguenay Power Company, Arvida, Que.
Furanna, A. L., Queen's University, Kingston, Ont.
Garvie, W. L., Canadian General Electric Company, Peterboro, Ont.
Gilbreath, J. H., International Nickel Company, Copper Cliff, Ont.
Hales, J. M., Canadian General Electric Company, Peterboro, Ont.
Henry, L. G., Canadian General Electric Company, Peterboro, Ont.
Leckie, D. H., The Steel Company of Canada, Ltd., Hamilton, Ont.
Niergarth, E. W., Bell Telephone Company of Canada, Montreal, Que.
Norman, J. A., University of Toronto, Toronto, Ont.
Rapsey, W. W., Canadian General Electric Company, Toronto, Ont.
Robinson, H. M., Amalgamated Electric Corporation, Toronto, Ont.
Thomson, G. T., Hydro Electric Power Commission of Ontario, Toronto.
Wolstencroft, E., English Electric Company of Canada, Ltd., Vancouver, B. C.

Total United States and Canada—496.

Elsewhere

Anderson, L. F., A. Reyrolle and Company, Hebburn-on-Tyne, England.
d'Enis, F. B., Metropolitan Vickers Electrical Company, Ltd., Manchester, England.
Garcia, I. M. A., 20 Sol Street, Arroyo, Puerto Rico.
Khalil, K. A., Central Prison, Haripur Hazara, Northwest Frontier Province, India.
Martin, P. C., Porto Rico Telephone Company, San Juan, Puerto Rico.
Nelson, M. H., Pioneer Mill Company, Ltd., Lahaina, Maui, T. H.
Rosas, J., Mexican Light and Power Company, Ltd., Mexico, D. F., Mexico.
Saade, F., United States Magnetic Observatory, San Juan, Puerto Rico.
Schechter, M. A., Manila Electric Company, Manila, P. I.
Soto, R. S., Mayaguez, Puerto Rico.

Total elsewhere—10